CHAPTER 1

Connections between trade, axes and quarries

1.1 Introduction

Distribution as trade and exchange of material goods is a phenomenon of human groups. It is an activity where goods move between groups across the landscape and are exchanged by means such as trade and gifts. Trade and exchange are interactions between individuals and between groups, in which the essential aspect is the mutuality of the interaction between the provider and the acceptor. The offer and the acceptance are also conducted along some line of connection or network of relationship. The path of this exchange results in items of material culture crossing some boundary that may be based on resources, such as an absence of material in one region, or is social and cultural in construction.

The possibility of being able to distinguish one form of exchange interaction from that of another makes the archaeological investigation of exchange worthwhile. The problem is that exchange as a human behaviour cannot be observed directly in the archaeological record; exchange is inferred. Only the effects of a human interaction can be accessed in the material record, that is from the objects to behaviour, and then to exchange (Torrence 1986, 226). The need to infer the behaviour of people in the movement and transaction of goods gives rise to problems of equifinality, that is where several different behaviour patterns result in a similar set of material circumstances in the archaeological record. Archaeological research in trade and exchange recognises the problem and the need for caution in the inferences made (Torrence 1986, 22; Bradley and Edmonds 1993, 10). Exchange is often used to describe the nature of the movement of materials across the landscape of Australia (McCarthy 1939; Mulvaney 1975; McBryde 1986). For exchange to have any explanatory power there must be a theoretical framework and a method that results in the identification of material correlates in the archaeological record (Torrence 1986).

The question of the motive for the exchange interaction is primary. The motives for movement of goods between human groups is likely to vary between different groups. How this differs is a problem of the variability of human behaviour. Human groups engage in an activity of transforming resources and creating value (see glossary) by making, exchanging and consuming items of the material culture. The result of the modification of raw material is an item of material culture which, in turn, is the material available to an archaeologist. What these items of material culture can offer as explanation in the prehistory of human groups is treated by archaeologists in different ways or with a different emphasis. My approach to trade and exchange is through the study of these economic (see glossary) transactions at the point of manufacture and to do this I develop a framework for a value-adding model of economic transactions and test it using two axes quarries.

1.2 Distribution systems and economic activity

In the human groups of prehistory there was a social structure, and economic organisation, and how these relate to each other is not always agreed upon. Anthropological research in trade and exchange is connected to the problem of the nature of interaction between groups of people. The question of 'why trade or exchange', can be investigated as an economic problem or as substantially non-economic phenomenon. I have chosen to study these movements of items of material culture (which I refer to as 'goods') as an economic problem. There is always some element in an economic exchange that can be considered as non-economic, but the important point is that economic factors are preponderant. My purpose is to evaluate trade and exchange patterning through a theory derived from a formal economic approach. The approach explores the possibility of explaining two levels, one of exchange and the other (more specific case) of trade for gain, and focusses on differences in the data sets and change in practices in prehistory.

Since Malinowski's ethnographic study of exchange in Melanesia (Malinowski 1922) economics has become central to anthropological questions. In one direction the formalist approach to economic anthropology analyses the behaviour of all societies within a framework of neoclassical economics, where economic behaviour is (mostly) held to be universal in its applicability to all societies at all times (LeClair 1962).

In contrast the substantivist approach argues that production and distribution processes are organised on different principles from that of formal economics (Dalton 1975; 1977; Sahlins 1972). Polanyi (1944; 1975) developed this argument and investigated principles which regulate exchange and distribution of commodities in non-market economies where the profit motive does not determine the nature of transactions. His analysis embeds the economy of a society in the socio-cultural matrix of that society. For Polanyi economic systems run on non-economic motives, such as the reciprocity of kinship in tribal groups and the redistribution practices of early state societies. In these circumstances, an economic system reflects the social relations that are bound up with the production of the material means of existence (Sahlins 1972).

The focus of analysis is exchange, with both Polanyi and Sahlins taking an ethnographic and historical approach. In this way they have a viewpoint distinct from the neoclassical economics paradigm.

The difference between substantivist thinking and economic formalists is that substantive analysis sees different societies organising economic activities in different ways. In the substantivist argument exchange cannot be seen in purely economic terms, but is an interaction in which social and economic organisation is important. In formalist economic analysis all societies exhibit certain economic features in common and the behavioural principles of choice operate everywhere (Knapp 1985). But in all cases, approaching the problem through economic behaviour is important for economic anthropology. Both substantivists and formalists agree that knowledge of economics should figure explicitly and importantly in economic anthropology, but as Dalton (1969) has pointed out, fieldwork and synthesis in economic anthropology suffer from inadequate theory. In archaeology views of subsistence and the place of items of material culture are valuable where they can be connected to economic behaviour.

One general viewpoint suggests the precapitalist small-scale societies were engaged in an economic activity that supplied items of the material culture along a continuum of behaviour. McBryde has also discussed the difficulty of recognising exchange in prehistory, in this case from the distribution of stone axes in east Australia, and commented that the fact of dispersal must be distinguished from the interpretation of this fact (McBryde 1979, 116). She argues that the model of trade found in describing the Neolithic farming cultures of Europe is not relevant to Australia (McBryde 1986). In contrast her model for Australia is strongly influenced by ethnographic studies of exchange, mostly recorded from the north of Australia (see Thomson 1949; McCarthy 1939; Berndt 1951; Mulvaney 1975).

Research early in this century suggested a commercial trading form of exchange from the obsidian quarries on the Greek island of Melos, partly because of the large volume of debris at the quarries and the pattern of obsidian distribution. Torrence (1986) tested this proposition and concluded the model for types of exchange was valuable, but that production and exchange from Melos across the Aegean sea was not based on commercial trading activity. Predicting when and under what conditions exchange will take place is an important task, because it cannot be assumed from the movement of materials across the landscape. As Torrence has pointed out, the problem in identifying types of exchange occurs 'in attempting to specify the exact nature of the links among such behaviours and exchange in concrete terms that have material consequences in the archaeological record' (Torrence 1986, 39).

What Torrence's approach uses, which was of value to my study of the production process, was the idea that the quarries are a part of the whole exchange system connected to all other parts. The connections provide material correlates for human behaviour associated with exchange as the movement of goods and will establish a trajectory and pattern of use for these goods. In this way, exchange can be incorporated into a framework of acquistion, production, distribution and consumption that has material correlates.

I have chosen to study the movement of goods as an economic problem of trade or no-trade, using a development of rational, maximising economic theory. The value-adding model of economic transactions is a perspective on making and distributing axes based on a formalist approach to economic anthropology. The basis of a formalist economic approach is conventional economic analysis in which performance is measured. Where choice is an important factor in behaviour, as I argue it is in the making and distribution of axes, then formal economics provides a relevant framework for analysis.

1.3 The thesis problem

The problem I address is whether economic transactions based on trade for gain drive material exchange in the small-scale societies of prehistory and whether these processes can be seen archaeologically in axe quarries. I use the term 'trade for gain' to describe an exchange transaction between groups or individuals where the terms of the trade agreement alienate the goods from one party to the other. An alienated transaction is completed by the agreed terms of the transactors and does not have continuing and unspecified obligations.

My approach to activities at the quarries proposes trade and no trade as outcomes. Testing the hypothesis for trade-driven production and distribution resulted in either trade or no-trade. In the model no trade covers all other cases, including casual procurement. The procurement strategies could be formulated in terms of trade networks, direct procurement through special purpose trips, or logistic strategies embedded within seasonal movements (Morrow and Jefferies 1989). Problems can arise where there is only one raw material found at a site, such as at a quarry. Without a theoretical proposition the difference between casual procurement and trade-based acquisition cannot be distinguished in the archaeological record. The material correlates of these different procurement strategies must be clearly distinguished.

To use a formal economic model for analysis there must be some boundary conditions, and for this purpose I have assumed that no other factors were at work in my case studies. The boundary conditions I have adopted test for a situation of trade or no trade. In some cases it is possible to suggest the form of activity, such as casual procurement rather than trade, but other ways of procuring axes are not tested. Other factors may operate in the procurement of stone. The literature describes ceremonies where exchanges of goods take place (Stanner 1933-34; Thomson 1949), or people journey to quarries to request axe stone from the kin-based groups who control access (Myers 1982; Howitt 1904). My study is not directed to an evaluation of the institutions through which goods pass and so these situations are not tested. The production possibilities are the same as in my study, but the tests are limited to the nature of production. For example, the kin-based group controlling the quarry may make axes and trade these at a ceremonial occasion.

I narrow the problem in my thesis to evaluate whether the dispersal of axes across east Australia is organised on the basis of economic transactions in which the goods are exchanged as trade for gain. If they are, then there will be expectations about the nature of production at the axe quarries consistent with the system of distribution. I have developed a single specific economic model of transactions based on the value-adding decision process in axe making by which to test the data I have collected from two axe quarries in east Australia. The value-adding economic transactions model is a particular form of economic model based on choice and the relationship between cost and revenue in decision making situations (Eatwell and Millgate 1987).

My approach to the problem of appropriate means for the explanation of production, exchange and consumption for stone tools in prehistoric societies differs from other recent studies. Torrence's study of production and exchange of stone tools was a theoretical and methodological formulation of expectations along a continuum of exchange types from reciprocity to commercial market exchange (Torrence 1986). She tested this on a single site case study of a stone quarry and juxtaposed the possibility of commercial market exchange against direct access for procurement from the quarry. Study of production at the quarry was based on cost-control measures and was monitored by traits of efficiency in stone tool making. The distribution of stone from the source at Melos was directional across water to sites where the obsidian was recorded as part of the debris (see Renfrew 1975).

Bradley and Edmonds (1993) addressed the problem of the changing significance of the axe trade in Neolithic Britain by using a case study from a source for stone in relation to the distribution and consumption of the axes. They criticise the formalist approach and argue there is 'no intrinsic reason why the relationships between production, distribution and consumption should be either predictable or direct' (Bradley and Edmonds 1993, 11). Questioning whether the limited methods available in processual archaeology (such as formal economic analysis) can offer a satisfactory framework for measuring exchange, their approach is to locate the study of exchange in its social context. In their approach the nature of the social relations under specific historical conditions are more valuable than are processes for interpreting trade and its material correlates. They investigated social contexts of the circulation of axes and the conditions of axe manufacture. The axe source at Great Langdale in Cumbria had differences within the quarry and from different parts of the site in production technology and possibly the direction of distribution.

I use the relationship between production, distribution, and consumption as being in a direct connection with the type of exchange operating in the axe trade. This processual approach differs from the inductive and contextual approach developed by Hodder (1982) and followed by Bradley and Edmonds (1993). My study differs from that of Bradley and Edmonds in that two axe quarries in Aboriginal Australia are compared, for differences in production technology related to exchange types in the distribution system. Their approach to understanding the role of items of material culture in the small scale societies of prehistory is based on social reproduction (Mauss 1925; Gregory 1982). In contrast my study follows a more processual form of analysis, and there are implications for method arising from this difference. The differences I seek between the stone knapping at the two quarries are not directed to change in understanding of production over time, in the way discussed by Bradley and Edmonds.

Yet their methodology is valuable in recognising developments in understanding production technology in stone tool making. For example, the development of our understanding of the technology of production in prehistoric stone working has moved from single generalised reduction sequences (Collins 1975) to sequences of stone reduction with multiple and bifurcating trajectories which will vary from one production site to another (Nelson 1991; Shott 1994). Bradley and Edmonds (1993, 46) attack what they see as the 'uncritical use of modern economic principles' for models of the axe trade in prehistory (Boydston 1989; Elston 1991). But the archaeological study of prehistory must find ways to link the statics of the material record with the dynamics of past behaviour (Binford 1972; 1977; 1983). The approaches are designed to offer arguments and partial models of reality against which data can be tested and evaluated with the object of progressing to a better fit for what is known from the material record

(Torrence 1993; 1994: Torrence *et al.* 1992). My study uses 'modern economic principles' as they develop in testing with data and structures in the prehistoric material record.

In contrast to Bradley and Edmonds, Torrence made the development of an appropriate middle range theory central to the study of production and exchange systems. Torrence's study of Melos (see Torrence 1982 to 1986) is designed to test the method she developed for the differences in production and distribution for exchange. In her study the sea-borne distribution across the Aegean is in a one-way direction, where my distribution of axe stone can be regarded as a step by step movement (which appears as a scatter) across the landscape. The result of her approach is to distinguish between trade and direct access.

The justification for testing my model is that it differs from other maximising models of economic behaviour, in which optimisation principles are set in a rationalist framework of analysis. My model develops economic decision-making principles along a trajectory in a value-adding model of transactions, where efficiency exists in particular circumstances. The model I test also differs from the substantivist model of economic anthropology, and from explanations of the phenomenon set in social terms. Exchange based on the value-adding economic transaction model is a specific form of exchange, and accepts that not all exchange is driven by (what I term as) trade for gain (Sahlins 1972; Polanyi 1944; 1975).

To distinguish the particular form of exchange I want to test there must be some means of recognising exchange types in the prehistoric societies of Aboriginal Australia. These non-trade exchange systems (such as delayed, balanced reciprocity) have been extensively documented in ethnographic studies around the world (Malinowski 1922; Harding 1967; Cashdan 1987; Wiessner 1982). I make this distinction by means of axes in exchange having symmetrical shaping. My argument is that: before trade for gain could develop in east Australia axes were distributed in an exchange system and that these axes were recognised and accepted by people in the exchange system as being exchangeable because of their symmetrical shape.

Analytically (and probably temporally) the feature of exchangeability in an axe will precede the value-adding economic component which developed within an already existing system of distribution. From the symmetrically shaped axes in an exchange system some groups developed a value-adding economic approach to axe making, in which efficient manufacture increased the (revenue) gain available to them from transactions with user groups. In this system of distribution symmetrical axes are independent of the value-adding economic production of axes, but these axes made for trade will be both symmetrical and made in a cost-efficient manner under the value-adding economic transactions model.

1.4 Economic resources and economic transactions

The movement of items of material culture across the landscape involves the movement or use of resources. In some way these resources are 'economic', that is there is an allocation of scarce resources between a number of other competing opportunities. Allocation in relation to an economic resource in prehistoric society must be distinguished from access, which is a question of political control over resources in a society. Economic resources are the product of an infrastructure and a perception of the material world, and these resources in an infrastructure may be tangible and physical, or they may be organisational aspects. For example a stone quarry is a tangible and physical resource, but a ceremony is also a resource-based activity: 'behind the mask is a man; behind ceremonies are resources' (Ericson 1981, 92). What is economic in this situation will depend on the perception held by people of value in the object.

Stone in situ as a natural material may or may not be an economic resource. The status of the material will depend on the perception of the people who have knowledge of the material and how this relates to the economic system. At some times and in certain conditions a stock of material will be 'economic' and at others there will be no economic value attached to the resource. The resources are perceived as having economic value to the exclusion of other material stocks on a shifting pattern that relates to the activities of human groups. Under these circumstances a raw material stock such as a stone axe quarry may be perceived as an economic resource and operated as such by a group of people. Yet this may not always have been the case for this material resource. At other times, procurement patterns for stone may have been different; axe stone may have been drawn from cobble resources or pebble banks and not from solid rock outcrops. Loose cobbles were the perceived resource and the stone outcrop suitable for axe making would have gone unrecognised. Economic value does not exist for the stock of raw material found in a quarry, until the resource is perceived as being in demand for the production of axes.

The exchange of items of material culture between hunter-gatherer groups recognises that value is attributed to certain objects. Renfrew (1986, 158) describes value as something 'assigned' to a product by an individual or a group, and argues that with the relevant material evidence, value can be observed and evaluated cross-culturally. Value is not an inherent property of the resource but comes from the perceptions of the resource by the people who come to think of it as a resource. It is a product of how the people who use this resource have structured its place (as an exchange or trade good) in the material culture. This 'value' is what draws objects into an exchange (or trade) system (Simmel 1978; Stigler 1961; 1966). Value in this sense must be distinguished from 'worth' in that the term value refers to something of relative worth (Anderson 1993). The value of a good is related rationally to other goods and the relationship is usually expressed through money. The worth of something is intrinsic and is valued as an end in itself, without providing any guide to the rational value of other things.

The concept of value has been applied to problems where unpriced decisions are the basis of choice, that is where there is no price system available to order these choices (Sinden and Worrell 1979). Under these conditions value is a useful guide for decisions because in exercising choice people do not make general or universal decisions, but make limited choices which are not regulated by price measurement. The limited choices available establish comparative values between alternatives and result in specific decisions being made, which appear to be the best solutions to specific problems.

Value for the material stock held in the landscape may, in economic terms, be signified by (and result in) restriction of access to resources in hunter-gatherer groups. As Tindale points out about behaviour in Australian hunter-gatherer groups, 'when they could retain title to the sources of these riches, they had something to offer and much to defend' (Tindale 1974, 81).

The fact of dispersal of stone axes in eastern Australia raises questions about the reasons for goods moving across the landscape. One economic reason for the movement of goods among human groups is based on the availability of goods in one place and absence and demand in another place. How demand can be satisfied depends on factors related to economic systems. For example, the organisation and nature of the production and distribution system is important in the case of a resource which is located at one point, as is a stone axe quarry.

The economic motive for the movement of goods revolves round the concept of scarcity. In Australia scarcity may be the reason for movement of goods such as stone axes. A comment taken from Tindale (1974, 81) again shows this: 'the almost total absence of good stone for implements on the silt plains was alone an inducement for the passage of these and other materials'. In this assessment of the reasons for the movement of goods in eastern Australia the factor of scarcity is fundamental. Scarcity is a perception among one group of people as an absence, and this situation can be altered by demand which can be satisfied by supply from another direction. The people of the silt plains must know about axes available in the east for there to be any perception of scarcity. Absence of material in one place may be supplied from another place. This may be true in a situation where raw materials are transported from one place to another. For example, Thomson (1964) reports the Central Desert people carrying raw material from one camp to another in their subsistence round. The economic value of a resource is recognised and made tangible by transportation. The absence may also be recognised in a society by supply with items like stone axes from distant sources. In these circumstances, the economic value of a resource is established by its value in an exchange.

Scarcity as an economic motive can be seen as part of the problem of what induces production at a quarry. Production can be initiated either by direct request from visiting people to quarry owners, or anticipation of an event (such as ceremonies) where trade or exchange can take place. In either case there is a demand influence on the production of the items of material culture. I define demand as a specific set of circumstances, that is, where there is an agreement between the transacting parties about the point on the scale of values at which goods are exchanged. In economic theory demand exists at a specific price agreed between the parties; it is not an unconstrained demand for all goods at all prices. In the economic model I propose for axe production and distribution systems the constraint of demand being operative under specific circumstances must be applied to transactions (Runnels 1985). The problem of demand as stimulus to production in hunter-gatherer societies such as Australia is whether there is a mechanism (like the profit motive in commercial market economies) by which to organise a response of increased output. Or, whether there are limits to the capacity of hunter-gatherer societies to respond to demand by an increase in production (Sahlins 1972; Dalton 1962; 1975).

In summary, my economic model is founded in the maximising and optimising approach from economic theory (Arrow 1987) and followed by formalist economic anthropologists (see Le Clair and Schneider 1968; including Godelier 1972; Hill 1988). The approach I use differs from the strict maximising models by the process of value-adding (being decisions made by axe producers in the economic system) and the constraints imposed by different trajectories for the output. A linear economic approach based on maximisation would disregard the possible conflict associated with value-adding decisions (discussed in Chapter 2) which maximise the revenue from axes offered into an exchange system and the other material outputs from the same process.

1.5 Stone axes and axe quarries in Australia

The stone axe (Glossary) in Australia represents a unique archaeological resource in that few items of the material culture travel so far across the landscape and pass between so many different groups. The 'axes' which (as the products of quarries) form the basis of this study have been described by McBryde (Binns and McBryde 1972) as 'ground-edge artefacts'. This description of the study material gave the distinguishing trait of what are often called 'axeheads' as stone with the property of being ground on the edge. My research questions are in the products of hard rock quarries, both in their potential uniformity and their diversity. For this reason I take an 'axe' to include products which are not ground edged, but possess certain shaping features. I discuss these features in Chapters 4 and 5.

Other items of the material culture will circulate between groups, but the problem with other materials is in their potential for preservation. Many items of the material culture in circulation have a poor preservation rate. When Mulvaney (1975) reports that almost every item of the material culture entered into exchange, the problem is which of these will survive in the archaeological record. For example, the long stems of rushes used for spears are reliably reported as being traded into north-west NSW from groups in the interior. They are valued and sought after by the groups, but the material does not survive in the archaeological record. In these circumstances, stone axes hold an unusual place in the circulation of items of the material culture. As McBryde (1984, 267) has commented, archaeologists 'now see (the Australian hafted stone hatchet) as having special value for studies of production and distribution, trade and exchange'.

The geological features of an axe give the possibility of an archaeological investigation of origins. The connection of stone axes from one part of the landscape to a rock source in another part is an opportunity to evaluate the dispersal of material goods, and relate them to a point of procurement and production. A stone axe found as an isolated item of material culture can be connected to a specific source. The connection makes possible the archaeological analysis of stone axe dispersal as a study of trade from the side of supply (that is, production) to consumers. The largest body of archaeological material associated with the dispersed axes is found at the quarries. The quarries are numerous and the products are found in many different patterns of dispersal. The situation gives the opportunity for archaeological investigations and interpretation of the dispersal as indicators of exchange between groups.

I have suggested that in Aboriginal Australia exchange can take place between groups as a trade-based economic transaction. To evaluate the nature of exchange in the small-scale societies of Aboriginal Australia a set of predictions and a method of analysis is needed. Testing predictions for exchange as an economic transaction is done through the archaeological record for stone axe making and dispersal in eastern Australia. In Australia there is evidence of dispersal of stone axes from their source in several patterns (Binns and McBryde 1972; McBryde 1984; 1986; 1987; Davidson *et al.* 1992).

Predictions for exchange as an economic transaction will have expectations associated with the economy of raw material acquisition and usage. For a set of circumstances where the expectations for the production and distribution of stone axes are to be evaluated, a case study in eastern Australia is needed. Specifically, two quarries from which there is a known dispersal of stone axes were chosen for study. The quarries met certain conditions for them to be suitable for study. One of these conditions has already been mentioned in the pattern of dispersal from the quarries. The quarries must have the debris and preform axes on the site with a sufficient standard of preservation to warrant study. From these quarries there must be sufficient data with which to compare and contrast the (different) conditions under which axes were made and distributed. The approach is described by Torrence (1994) as searching for difference between data sets. The method she describes is to examine an area of human activity (such as axe making) and then to explain how this operates in economic systems. How an activity such as axe-manufacture makes this contribution, comes from comparing and contrasting cases.

The place of origin and processes of manufacture are important to my study. Roth commented in the late nineteenth century that the location where goods in exchange are collected is often known and recorded, but that 'the particular tribe or district which originally manufactured them' is not known (Roth 1897 [1984], 136). Two quarries were suggested by McBryde as being suitable for the case study: one at Gulgong in the central tablelands of New South Wales (NSW); and the other at Warren in western New South Wales. The method used to establish whether the production and distribution of stone axes in eastern Australia took place as an economic transaction is by means of the axe making processes and organisation of technology at the quarries. The data base of two stone axe quarries of distinctive and characterised raw material is designed to compare and contrast the material remains and the inferred behavioral processes at the sites.

1.6 Contribution of the thesis

My study contributes to the archaeological problem of distribution systems in the following ways. The thesis contributes to the need for theoretical frameworks which can be used to explain different ways in which an economic resource can be acquired, produced and distributed (see Torrence 1986). Analysis of production and movement of items of material culture across the landscape of east Australia contributes to understanding the nature and motive for interaction between social groups in prehistory. If the evaluation of production and distribution of axes is based on value-adding economic transactions resulting in trade for gain, then the question of why people in prehistoric societies aggregate and interact with each other is more accurately explained. If my evaluation of axe making and distribution from the two quarries does not support a trade-driven basis for the behaviour, then opportunity for other explanations is opened by rejecting this specific hypothesis.

The thesis contributes to the archaeological analysis of distribution systems by distinguishing between axes made as a value-adding economic transaction which are distributed by trade for gain and the wider concept of symmetrical axes made for exchange but not necessarily on the basis of value-adding economic transactions. This approach develops the precedence of exchange processes for small-scale societies in prehistory over economic transactions as trade for gain.

My thesis tests the feasibility of research at quarries, given the type and condition of the archaeological material likely to be found there. In particular the kinds of measures which can be made and the value of quarries as archaeological sites for research. Several different approaches to analysis were needed, to give the diversity of data sets in order to contrast with aspects of the problem tackled and from this my model produced valuable results on the nature of production at axe quarries. I extend and expand the reduction sequence for tool making and integrate this with a trajectory for the production and use of worked stone material from the quarries. It requires a close look at selection, extraction and shaping of stone used for axes, and an analysis of the toolkits used in axe making at the quarries. The results of axe making, especially the recycling of part finished material from the stages of the reduction sequence and the place of hammerstones, have not been widely discussed.

I test propositions on symmetry in Chapter 5, and on axe making at the quarries in Chapters 6, 7 and 8. Before these Chapters I develop theory associated with the value-adding economic model and exchange in Chapter 2. To assess the value of the two quarries used in the case study in Chapter 3, I describe and evaluate the distribution of axes in east Australia in relation to known quarries for axes. The data available from the two quarries and potential for analysis is presented in Chapter 4. My conclusions on how well the tests worked and the nature of exchange in Aboriginal society is discussed in Chapter 9.

CHAPTER 2

Exchange and value-adding, efficiency and symmetry

2.1 A framework for axe making

In Chapter 1, I discussed the main themes of production and distribution of axes. In this Chapter I propose how exchangeability of products and value-adding influence the behaviour of axemakers and introduce concepts of efficiency and symmetry used in axe making. Together with the previous concepts they frame the method by which I have investigated the selection of raw material and making of axes. To illustrate how these themes are used to make predictions about specific behaviour at the quarries, I propose a trajectory from production through distribution to use in Aboriginal society in which the general reduction sequence for axemaking is included (These are presented in Figures 2.1 and 2.2).

The scheme of connection between concepts in the thesis is given below and the relationship between efficiency and symmetry is discussed. My discussion is organised according to the following themes:

A. Factors relating to distribution:

(1) exchangeability, and
(2) value-adding

In this section I discuss: the exchangeability of axes based on recognition and acceptability as being of a type intended for circulation and use in a distribution system; and the role of value-adding in structuring the making of axes for exchange, that is where exchange is based on an economic transaction.

B. Factors relating to production:

(3) symmetry, and
(4) efficiency

Symmetry and efficiency are concepts which exercise control over the actions of knappers in axe making. Efficient production of the axe preform does not depend on symmetry in shaping the mass. Efficiency and symmetry are both components of control in axe making, but are independent of each other. Control through knapping practices which results in efficiency in production will come from knapping action, just as the symmetrical shape is the result of action by the knapper. But the purpose of the actions resulting in efficiency and symmetry are different. Symmetry is directed towards the exchangeability of the axe and efficiency is related to the nature of production, especially the means by which cost reductions are achieved. Efficiency becomes relevant to the production and distribution of axes where they form part of an economic transaction.

Definitions of efficiency in economic literature are not easy to apply universally. For example, the everyday use of the word is general, suggesting competance and the ability to perform a task under given constraints. In my study efficiency is an economic idea. There are specific conditions in economic analysis where efficiency is identified as a unique point on a range or scale of possibilities, such as with production possibility curves, and from which a set of actions will ensue. What is universal in economic analysis is the notion of a relationship of energy or effort as an input to an outcome or output produced.

The efficient actions on which the archaeological study is focussed, are constrained by economic processes. These economic processes are registered by parties engaging in, or drawing away from, exchange transactions. Information in manufacturing and interaction between persons in the transaction will result in the producers perception being changed. The other courses of action available in axemaking are assessed and decided by the producer.

The process of value-adding is not the same as operating under conditions of efficiency. For example, efficiency is one means of adding value to an output and innovation is another (Van der Leeuw and Torrence 1989).

The level of the economy at which efficiency operates as a trait in economic systems can be clarified by contrast with innovation as an economic action. Innovation is a process in which there are once and for all changes in the way things are done, in either labour, capital or organisation. But innovation can be observed at a level where the events are aggregated into a process which is continuous over time (see van der Leeuw and Torrence 1989). Efficiency is a continuous practice operating within the environment of innovation and change, and is often aimed at cost reduction. The benefits from efficient action in an activity such as stone axemaking occur within the stages of reduction of the production process, and has limited objectives in cost control. In that sense the efficiency described is the best course of action only to the outcomes required from the tasks of the particular stage of production. What is required within the stage of reduction will be best achieved on the basis of what is required as an output. The input to that part of the process will be set by the actions taken in the previous stages of reduction. At this level efficiency is measured within stages of reduction as a production activity with limited objectives, which is cost-controlled at that point in the manufacturing process.

In contrast to efficiency, innovation operates at a level where there are changes in the use of various stone resources. The movement of axes around the landscape appears to have been taking place for some time before 4K years ago. One situation is represented by pebble axes and polished, waisted or heavily notched axe heads, of which there are few in number and scattered widely. There are a few axes dated from late Pleistocene to early Holocene in the north of Australia. In contrast to this there appears to be an intense exchange of axes in the late Holocene, from about 1.5K years ago to 800 years ago, in which a large number of stone axes were made over a short period of time (relatively speaking). The situation suggests change in the production, distribution and consumption of axes in Aboriginal society. Change and new challenges (possibly new networks) appear to stimulate production in quarried axes and to a change in production methods during the time the quarry was in operation. The shift to quarries as a source of stone is an innovation in procurement practices at the level of the use and organisation of the resources available in the Aboriginal landscape. The way in which axemaking is undertaken at quarries will have aspects and consequences related to efficient behaviour.

In this chapter I discuss the factors relating to efficiency in value-adding, and of symmetry in relation to exchangeability.

2.2 Value-adding economic transactions

Economic transactions use scarce resources, and the use of these resources are based on choices made between other opportunities. In this situation value-adding is a decision making process determining the economic choices available to the producers about the use of the scarce resources at their disposal or under their control. Value-adding as an economic concept has features similar to cost-benefit calculations in economic analysis. They are similar in that the benefit expected from a decision must exceed the cost or input required to achieve the output. Both encompass ideas of efficiency and efficient actions. My use of value-adding as an economic decision differs from cost-benefit calculations where optimisation decisions establish goals in economic behaviour (Torrence 1989; Boydston 1989).

Value-adding goals require decisions about a range of economic opportunities, but the concept accepts limitations on the rationalist maximising outcome found in cost-benefit analysis. For example, a decision to further process axe stone from (say) the blocking out stage of reduction must also accept an increased number of manufacturing failures. There will be other trajectories in production and distribution for these production failures from the intended output of axes for distribution in exchange systems, such as for hammerstones and axes in local distribution (in Figure 2.2). But the number of manufacturing units passed into these other uses is determined (in part) by the decisions of producers on the number of axes intended for the exchange system, and the capacity of the other parts of the production trajectory to take up these redirected axes. A shortage or surplus of worked material for hammerstones, or in the axes for local distribution, results from decisions made about the point at which value-adding transactions will take place between producers and consumers.

A material can be transferred (transacted) from one person to another at any time after the first person has selected the material for conversion into a product. At the point where material is passed over to another as an economic good, the conversion process undertaken by the first person to add value to the object, will stop. The conversion process may be in the form of labour and other factors of production (such as capital tools) being used to modify the raw material. I assume that modification of the raw material is intended to increase the economic value of an object transacted to another person or group, and that this is known to axe makers through the stages of reduction in the manufacture of axes.

The model I propose assumes a level of interaction between the persons engaged in the economic transaction in which people are active and respond to inputs of new information and to external situations, such as new conditions of supply and demand. Modification of the artefacts is the action of the maker, but the perception of economic value is one dependent on a degree of interaction in choice-forming and decision-making information by the buyer and seller. Whether an activity is value-adding from the perspective of the buyer will determine whether processing activities aimed at profit or benefit will add value for producers. Value-adding activity will only be profitable if the activity provides something of value to buyers for which they will pay, such as by exchanging other resources.

In the conversion process, more value accrues provided the actual changes or conversion of the raw material is in a direction perceived by the both the producer and user to increase value. The more stages of conversion raw material goes through, the more value accrues to the producer. The increase in value must be tested by some measure which is external to the producer's perception of value-adding. Where the value-adding component in the conversion of raw materials to a desired product is large, then the process will be strongly linked to the rest of the economy and the situation suggests trade. If the conversion process from raw material is minimal, the value-adding component is small and there will be less connection with trade-based systems. Economic systems where value-adding is high between producer and consumer will be trade-based, because of the direction of resources into further processing of the product before the good is passed to the consumer. The model I test at the quarries has potential for high levels of value-adding on the raw material in manufacturing an axe, and will draw high value-added goods into trade.

Most conversion of raw material will require labour and other factors of production and so the successive stages of conversion will also incur additional costs. As an economic transaction there will be a point in the continuum of value-adding when further conversion is not worthwhile. At the point where the benefits of additional value-adding are less than the cost increases from further processing, conversion will stop. There may however, be an advantage in further processing by the person acquiring the object. The advantage exists because of a different combination of factors of production.

Value-adding may involve a set of decisions related to the extent of conversion of raw material in a manufactured good. For example, stone axes may be completed to an advanced stage of shaping and thinning before being transacted to another group. Value-adding sets the framework of the transaction and determines the point at which the producer will offer to pass the object over to another group. The value-adding process will give benefit to the producer through increased revenue (in excess of cost). The user of the good, as the other party to the transaction, will benefit and receive a product with the quality and degree of completion required.

All axes are modified away from the quarry where they are manufactured. They will be further processed beyond roughing out and thinning in manufacture by, for example grinding the edge, and must be repaired and rejuvenated in their use-life. Economic value is related to the process of value-adding in the manufacturing process at the quarry. The value-adding process does not exist at all times and under all circumstances. For example, the knapping of stone for axes outside of the quarry system can be on a regular or haphazard basis, but it is not done under a value-adding regime described for the quarry.

The production sequence I describe at the quarry follows a pattern of value-adding to produce axes for trade. The axe making sequence does not necessarily result in axes suitably made for trade on a value-adding basis. My model takes all axes made at the quarry as being intended for value-adding manufacture at the point of input and accepts that some will be withdrawn for local use (see Tables 2.1 and 2.2). Those withdrawn for local use will not be those processing successfully along the value-adding production trajectory.

The modification of preforms in manufacture for trade is more than incidentally related to increased value in trade contexts. The axes are traded through the process of modification in the stages of reduction, rather than pieces of stone from a quarry being traded. There is a strong propensity to add value in shaping the stone, and this is more than incidentally; it is the reason for there being value-adding from the raw material. The steps in production are not only technological points in the manufacture of axe preforms, but they also represent points where value-adding takes place. For example, after selection and extraction of raw material the axe stone can be distributed away from the quarry, or it can be further processed through the stages of reduction as a preform. At each of these points the axe stone has value in distribution, but the further processing of the stone as an axe preform will add value in terms of exchangability, that is where the object is recognised and is acceptable in exchange transactions.

The difference between value-adding and efficiency is clarified by giving an hypothetical example based on the production and exchange of a mythical good.

2.3 Hypothetical example of a mythical good

To explain the relationship of value-adding in economic transactions to that of efficiency in the economic model of axe making, I will give a hypothetical example using a mythical good. The mythical good and the hypothetical example concerns the making of the good in the production process. The mythical good is the output of a process based on a raw material which is ubiquitous, although it varies in its quality and end-use. In order for the mythical good to exist as an economic good, the properties of economic value must be perceived by the consumers or end-users and producers respond. With 'producer' and 'consumer' in the same frame of mind about a good having value, there is then the possibility of an economic transaction taking place. Inspite of its ubiquity, the mythical good occurs in only a few places at a quality and volume sufficient to exploit and offer to other individuals or groups. The number of supply places used for production will vary depending on the demand for the product. For example, where demand for the product is high then new sources may be opened for production. In these circumstances the product is subject to the extent of demand placed on the supply by the end users, and the potential of the producers to supply the good.

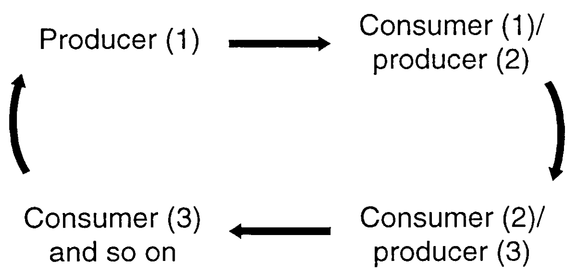
Value-adding is a decision-making process in relation to economic transactions between at least two groups of people, which I will call producers and consumers. In the chain of the transfer of goods there may be a set of relationships where one is a producer in relation to a consumer, but a consumer in relation to another producer in the line. An example of this relationship is where a set of exchange transactions have producers, middlemen and consumers in a directional pattern of relationship viz:

(1) Producers ⟶ (2) Middlemen ⟶ (3) Consumers

In terms of economic thought, where transactions are value-adding, then the middleman is a producer to the consumer, but a consumer to the original producer. An example, of an economic transaction which adds value by movement with no other conversion process, is when the good is transported by (1) producer to the ultimate (3) consumer. In my example, the illustration best takes the form of a bilateral relationship between a producer and a consumer. The chain then becomes a series of producers of one output and the consumers of this output, which forms an input to them. The movement then appears as one of a continuous set of bilateral arrangements between producers and consumers. These links are shown here in a linear fashion:

Producer (1) ⟶ Consumer (1) to become producer (2) ⟶ Consumer (2) to become producer (3) ⟶ Consumer (3) and so on ⟶

The arrows indicate the direction of the movement of the economic good in the transaction. In this linear model of the chain of economic transactions there is no defined original producer and no defined end user. The linear chain can be modified by recognition of a more circular situation existing in the reproduction of goods amongst and between people in groups. In contrast in a circular system there are producers and consumers (as end users) connected to each other in the cycle. The model in this cycle will look more like the following:



I do not develop the difference in perspectives of these two models, but use the example simply to demonstrate the role of value-adding.

In economic transactions, decisions are made about the direction and economic value-adding to the good at every point in the chain. The good is subject to a process which adds value at every point, otherwise it will cease to be part of the process. In terms of the manufacturing of this good, there is now a continuous process from producer to the ultimate consumer or end-user. I want to concentrate on one, more detailed part of this process, that is the manufacturing of the mythical product. Like so many processes, the making of the mythical good is best seen in terms of stages of production. This approach is found as the basis of process industries, such as the petro-chemical industry. In this industry there are many products in the output of a process, but the economic basis of transactions will control the type, quantity and quality of goods produced at different stages in what is a continuous process.

If producer (1) in the linear model of manufacture of the mythical product has a number of value-adding decision-making points, then these are important in the economic transactions conducted between producer (1) and the users or consumers. Producer (1) is in a position to extract the mythical good from a point on the landscape and to transact this with another person. At this point whether the good has an economic value will depend on the perception of value placed on it by another, in this case the consumer (1). Certainly producer (1) has invested effort in the extraction with the expectation of a result in terms of demand.

From this major step of extraction from a resource point, there is a decision process available to producer (1). This decision process is based on the economic transaction giving revenue in relation to costs. If there are decisions to be taken about increasing revenue, then this will also involve costs. Not all costs are the same for all actors in the economic transaction. The calculation for passing on the extracted product depends on the perceived revenues and costs to the producer (1) and consumer (1).

In effect the producer (1) may see an advantage in terms of increased revenue or cost saving by holding the extracted product and adding another stage of value to the good. This further processing of the good adds more revenue than cost. The situation requires that consumer (1) agrees to transact at this stage of the production process, rather than at the extraction stage or some later point in the process. The more stages producer (1) engages in before the good is passed on to consumer (1), the more value-adding takes place. This situation persists provided revenues exceed costs. It is possible for some consumers to be excluded from the process as the producer (1) extends along the chain of value-adding by supplying some consumers with late stage products and not others who want only those from the early stages.

Efficiency in the manufacture of the mythical goods will exist where the producer decides there is some advantage in revenue terms for the behaviours, or organising the production of the mythical good in one manner rather than in another. The basis of this efficient behaviour in manufacture will be in calculations of costs associated with different courses of action. One course of action will reduce costs and so increase revenue (all other things being equal) and another course of action will give higher costs and so reduce revenue (all other things being equal). The decisions taken about efficient behaviour will take place within stages of production and these stages are those found in the value-adding process. In other words, if there is some revenue advantage to producer (1) in value-adding by processing the mythical good through more stages of production, then the cost-control aspect of efficient behaviour will increase the revenue potential at that stage of production. There will be decisions resulting in traits associated with efficient behaviour in this part of the process, such as by-products which may be either further processed or distributed unprocessed. How the by-products are treated is a question of efficient behaviour. Whatever the decision, it is taken within the framework of value-adding.

2.4 Control in axe making

Stone knapping behaviour at the axe quarries is guided by concepts associated with expectations about the purpose of axe making and the conditions under which axes enter into the distribution system. I have proposed that the control in knapping and in the organisation of production seen at stone axe quarries operates to distribute exchangeable axes, with a value-adding economic model to guide production. These two features are implemented by means of symmetry in the shape of axes, and efficient control of the cost of manufacture.

2.4.1 Symmetry in control for axe making

Symmetry is connected to exchangeability, in that symmetry forms a criterion for exchange. Symmetry is the form and regular arrangement of the material in the body of an axe on opposite sides of a line or plane. The axis of symmetry is found in three possible forms, which I discuss in Chapter 5. These are symmetry: in plan; in the length from the bevel edge to the butt; and in cross-section (see Figures 5.1, 5.2, and 5.3). In my analysis I focus on symmetry in the length from the bevel edge to the butt and use symmetry in plan for contrasting features of material from Gulgong and Warren. I propose that the symmetrical shape of the stone axe, is the way in which axes are accepted as suitable for entry into the exchange system. My reason for using symmetry comes from studies and experimental work by researchers on axe shape in Australia and elsewhere and my own measurements of ground edge axes at the Australian Museum from two parts of NSW (see Dickson 1981; Best 1977; Bradley and Edmonds 1993; and my Chapter 5). But exchangeability of a symmetrical axe in itself will not make axe making a value-adding economic transaction. Symmetry is the only condition that will provide a suitable recognition criterion in the absence of some external template, or other, functional requirement, or stylistic distinctiveness. All axes symmetrically shaped will meet the criterion of exchangeability, but not all symmetrical axes will be produced as part of a value-adding economic transaction, because of axe production made and not traded.

The consequence of symmetry as a recognition feature in the acceptance of axes for exchange is different from the making of axes as a value-adding economic activity. Axes will not necessarily have been transacted solely and always on the basis of economic transactions; they may have been made and passed on as gifts (Mauss 1925). The recognition of exchangeability through symmetry suggests that goods were exchanged between interacting groups before any regularity appeared in the system of exchange transactions. From exchangeability, the value-adding model of economic transactions could develop as a means of supplying axes into a distribution based on efficient production and material gain. The exchange of axes can take place on the basis of symmetry as a recognition criterion, without the axe being the product of a system driven by economic efficiency. Over time the morphology of an axe in circulation and usage will alter and knapping features from the quarry will not be clearly observed on the surface of the axe. Only symmetry will remain as a guide to those axes which are traded and those which went into local usage.

The distribution and exchange of axes between groups is conceptually separate from the exchange of goods based on value-adding economic transactions. Logically, symmetry for the exchangeability of goods, will precede making axes by value-adding economic transactions. The opportunity for an exchange system based on value-adding economic transactions, will exist where exchangeability has been established by manufacture and distribution of symmetrical axes. What symmetry can do is to present an opportunity for axes in an exchange system to be made with a value-adding approach.

Where efficiency is the basis of axe making as an economic transaction, symmetry guides the preform manufacture as an exchangeable good. In axe making symmetry is evaluated through the morphology of the preforms in production and the reasons for abandonment at the quarries, efficiency is evaluated through flake features found on the preforms and in the flaked debris found at the quarries. An axe can be symmetrical in shape, but not made by efficient means. Both symmetry and efficiency require control in manufacture, but for different purposes and with actions which have different traits. The control in symmetry and efficiency will be evaluated through knapping features found on the work.

2.4.2 Efficiency in control for axe making

The conceptual framework of efficiency is a strong theme in quarry studies (Torrence 1984; 1986; Bamforth 1986; 1990; Baker 1987; Bradley and Ford 1986). There are problems and much to lead to uncertainty in the use of this concept (Bamforth 1986), but there is also strong potential for the use of the efficiency as a concept to guide research into technical practices and change at quarries and their output. The use of efficiency criteria is also a flexible approach to the analysis of many aspects of production and use of tools. For example, in the concept of curation where the Nunamiut collecters and hunters produced tool-kits with replacement and retooling features in their design (Binford 1972; 1977). These tools display efficient features in use (Torrence 1983; 1989).

Torrence (1986, 50) has proposed that the degree of efficiency will increase as the economy moves along a continuum of competition. From this it was predicted that along this continuum cost-controls in production would be more important as economic transactions become commercial (Rathje 1975). Where competition increases in the exchange of axes Torrence expects access to resources, such as quarries, to be restricted (Torrence 1986). The restriction of access to stone resources has been suggested to be the result of the operation of cost-criteria in efficient behaviour (Jeske 1989). My study is concerned with the technology and purpose of making axes at quarries and does not address the problem of the control over access to the quarry resources.

Efficiency is a measure of output per unit of input, and in making goods operates through the range of inputs, known as factors of production. The inputs to production which can be used to develop efficient behaviour in axe making are less likely to be the total of inputs than a single factor of production. In small-scale and hunter-gatherer societies single factor efficiency, especially labour, is the most relevant (Christenson 1982). Labour is important in small-scale societies because of the low level of capital investment found in such societies (Earle 1980, 10). With economic constraints on a general level efficiency in factors of production, especially a low level of capital investment, labour effort will be the focus of expectations for efficient responses in axe making.

In my study efficiency is treated as a cost-control device, where the benefit in the output from a defined action (such as a knapping stage of reduction) exceeds the input effort for that stage, rather than efficiency in the performance features of a tool in use (Torrence 1986; Rathje 1975). The aim of Torrence's research at quarries was to determine 'the degree to which the methods used to extract obsidian from the outcrops were efficient with regards to inputs of time, labour and technology' (1986, 171). As she puts it, 'the types of behaviour relevant for monitoring exchange are those that affect efficiency' (Torrence 1986, 49). In cost-control actions for production, the amount of efficiency accrued is related to productivity. Within the framework of value-adding to the product in process, efficient actions will alter the relationship between input and output. In effect an efficient action will give a better outcome for a given input, as compared with the next best alternative. The outcomes from one course of action or another will be known, but the process will not be automatic. The decision about an efficient course of action requires judgement and skill to implement the action. Efficient production of axes requires decisions about the manufacture of goods (such as stone axes) within the stages of production. One set of actions may be efficient behaviour in tackling a particular problem in the stages of reduction, whereas another set of actions will not give control over the outcome of that part of the production process.

In one way, an efficient effect is where objectives are achieved (Fare et al 1985). The decisions related to efficiency tend to be small-scale, as an optimising pattern within the stages of reduction. On the other hand, the desire to achieve efficiency determines the input actions in relation to the outputs in the stages of reduction. In effect, value-adding is the macro program in the transaction and efficiency is the micro behaviour within the transaction.

In summary, value-adding determines the point in axe making where the transaction takes place and requires a decision to be made. To that extent it is the rationale for the transaction as an economic action. Symmetry is the criterion of exchangeability for axes, and requires knapping control in axe making to achieve. Efficiency is the quality of the behaviour prior to the transaction and requires knapping control within the stages of reduction.

2.5 Symmetry in making and distributing stone axes

Symmetry can be attained at any stage of reduction from blocking out at stage 3 through to finishing (see Figure 2.1). In a value-adding process it is likely that symmetry will increase through the production trajectory, so that there will be more symmetrically shaped axes in the later stages of axe making at the quarry. Symmetry as a desirable output is frequently discussed in stone axe studies. Dickson (1981) considers symmetry as largely a performance property of an axe as an impact tool, but to Bradley and Edmonds (1993) it is an anthropological feature of an item in the material culture. As a feature important in economic anthropology, symmetry in an axe is something which can be ascribed (as inherited and desirable property) or assigned value by a group who are part of the transaction. In contrast, Davidson and Noble (1990; 1993) suggest symmetry may sometimes be an incidental feature of the knapping process, by which flakes are easily removed from the margins to maximise the usable flakes per core. These different views of symmetry are discussed in Chapter 5.

My argument is that axe making is associated with the use-life of the good. The form of the axe-head is developed along a trajectory from early production stages to the consumption phase, where changes in the shape of the axe will continue. In the distribution of axes from a source for which exchange may be described as the motive, there is no one 'axe' type but many different outputs across the range of axes. In Table 2.1, I present the various outputs from an axe quarry. The output of the quarry appears as a range of shaped and worked stone. Not all of these will be part of the exchange network, as other consumption patterns will also be in operation. The material evidence for this behaviour is demonstrated by the development of symmetry throughout the production trajectory and subsequent use-life (see Table 2.1).

Symmetry and exchange are connected because symmetry as a recognisable feature promotes the acceptability of the material object through design and form. There are several axe distribution trajectories in operation and not all of these have axes which conform to symmetry. For example, my model of the production trajectory for axes in production for exchange proposes that axes with no symmetry were locally distributed and used, whereas axes with symmetry were made for wider exchange.

Knapping control is required to attain the symmetrical shaping associated with the bifacial axe. This kind of control is a question of skill, not of efficiency (Pelegrin 1990). It can be achieved as part of the bifacial knapping process in a number of different ways. In the manufacture of axes as part of an exchange transaction, the production trajectory would be measureable along a line of symmetry. Symmetry gives a correspondence, or regularity, in size or form on either side of a line. Perfect symmetry need not be attained in the manufacture of an axehead, but this is approached. Like economic equilibrium the behaviour only tends towards the state. The preforms can be produced to a criterion that determines the manufacture from an independent requirement of symmetry in axe shape. The symmetry in shape is independent of the process of value-adding, although in axe making the two operate at the same time and in parallel. Where symmetry was developing from knapping a stone axe and the shaping stops before the attainment of symmetry, then the axe is assymmetrical and it can be passed into non-exchange use. Unlike steel axes, stone axes cannot be made to a symmetrical shape in one stage. Symmetry in shape requires grinding, but mass can be flaked and then changed for shape by grinding.

As well as during production symmetry can be maintained through the life of an axe head by means of tool maintenance, such as when the edge needs regrinding or by rejuvenation when the edge has been severely chipped. When symmetrically oriented axeheads are produced, some less symmetrical or asymmetrical pieces are also generated. They may not be abandoned as production 'failures', but can be distributed at an appropriate use-level. In the production of axes in Papua New Guinea, the asymmetrical by-products are distributed as work axes and stone for work axes from the product of the quarrying session (Salisbury 1962; Burton 1984).

In summary, the idea of symmetry is valuable for the study of the manufacture and distribution of axes. The approach I follow is to treat the exchange potential of the symmetrically shaped axe as the basis for the actions of the axe makers. This would suggest symmetry as design. In the discussion on symmetry as a guiding principle in making axes for distribution, I predicted that the exchangeability of the product was based on the degree to which it was symmetrical. But symmetry is not necessarily correlated with the efficient making of axes. Symmetry can be a component of the effective and efficient functioning of an axe, in that being better balanced, it functions more efficiently than a non-symmetrical one. This factor of symmetry may be incidental rather than crucial to the axe qua axe in exchange, although the functional aspect may be important in axe use and performance.

2.6 Methods for evaluating control in making axes

I now turn to discussion of efficiency as a method of investigating the rationale of production and the distribution of stone axes. The concept is then used in Chapters 6, 7 and 8 to test and evaluate the data from the quarries. In discussing the data I have concentrated on the following three aspects of axe production: (1) selection and extraction of raw material used in making axes; (2) manufacture of stone axe preforms; (3) toolkits used in production.

Torrence (1986, 48) points out that, in drawing inferences about behaviour from archaeological material it is not possible to observe efficient traits directly. To compare relative efficiency between situations an argument which 'warrants' the variables used as being relevant to the problem is required. Furthermore these features need to trace material consequences present in the archaeological record. To do this experimental work is often needed to identify the material features which are the result of control in stone knapping.

Given what we know about control in the flaking process and means of stone flake detachment, I predict that an economic transaction based on efficient behaviour would show fewer errors in flaking. One important flaking feature which is the result of error is a hinged fracture. Hinged features appear on flake debris and axe preforms at the quarries, and have been produced experimentally. My method of evaluating efficiency in the production of axes at the quarries was to record the number of hinged fractures on; (1) the axe preforms, and (2) the flaked debris, found at the two quarries. My expectation was that economic transactions would have few hinged fractures on the axe preform, and that the later stages of reduction would have fewer hinges than the blocking out stage.

Hinged fractures are not the only flake feature useful in registering knapping error. The features on flakes and preforms are relevant to control for reasons found in the techniques of axe making. Stepped fractures are often associated with hinging (see Edmonds 1989). They are more likely in some laminated rocks, but are largely associated with the amount of impact delivered for detachment. Ripples are suggested by Speth (1974) as ancillary and associated with hinge fractures and as such give another indication of problems in the application of the amount of force. Also crushed impact platforms are very relevant for measuring the degree of control in stone axe making. They can be expected either from direct percussion with a hammerstone or the use of an anvil block. An anvil is used in block on block form of direct percussion, where there is less knapping control than with a hammerstone. I have also recorded stepped fractures, ripple marks or undulations on the ventral surface of a flake, and crushed impact points. These are recorded in Chapter 4 and discussed in Chapter 7.

In summary, efficiency in the selection of raw material and in making axes is a viable method of assessing the extent to which distribution is based on economic transactions. Efficient behaviour is offered as tangible argument for trade as an activity with the purpose of economic gain. I take the presence of, and variation in, traits on the stone workings at the quarry to be associated with efficiency. Efficiency is registered by the degree of control in knapping axes, because more control gives lower error rates in production. Efficient traits can be recognised in stone technology, in that certain strategies give knapping features associated with degrees of control. These features are hinge fractures, steps and ripples. The differences in incidence and pattern of these features will suggest variation in efficiency between data sets.

2.7 General Reduction Sequence

In order to measure the degree of value-adding and efficiency in axe manufacture, I have devised a general reduction sequence, as a model of the manufacture of axes. The model covers behaviour from the selection of stone through a series of steps to grinding of the axe. Specific reduction sequences for the two quarries at Warren and Gulgong are presented in Chapter 7.

Reduction sequences for axe manufacture have been described by a number of authors (Crabtree 1967; Newcomer 1971; Bradley 1975; Burton 1980; Baker 1987; Edmonds 1989). They have usually been devised through experimental archaeology and are usually described in three stages, although along with other researchers (see Collins 1975), I would suggest that the production process is best understood as a continuum. The division into stages is carried out to facilitate analysis and interpretation of archaeological data.

The basis of a three stage reduction sequence is described in Crabtree (1967) as follows: the production of (1) a blank; (2) a preform; and (3) the finished implement. A blank is made by bifacially flaking a block of stone. The blanks are found in the early stages of reduction before a preform, and can result in several types of implements with no final form to the product. A preform has a finished form close to complete flaking on the surface and on the bevel. As an axe the preform will still have irregular edges, deep flaking scars, and no provision for hafting (Crabtree 1972). In some ways the difference between preform and blank is less relevant than with a core technology where flakes are produced as tools. In the manufacture of axes there are alternative ends for worked stone, but the technology of axe making dominates the reduction sequence. The use of blank, preform and finished implement describes the categories of reduction of the raw material selected for axe making.

This format for the reduction sequence has also been used by Bradley (1975), Newcomer (1971), Baker (1987) and Burton (1980), although Bradley includes an earlier stage of preliminary modification. Newcomer has described the three stages more in terms of the activities of the knapper, rather than the end product. For example, his description includes roughing out, thinning and shaping, and finishing. The emphasis on the activity in the process, rather than the result, is most noticeable in Edmonds (1989) description of the product. His sequences are; (1) testing and shaping; (2) mass reduction; and (3) thinning.

Using these general concepts, it is possible to make a series of expectations of how axes would have been produced from raw material at quarries like Gulgong and Warren. These can be summarised into six steps:

(1) selection of raw material
(2) extraction of stone
(3) blocking out
(4) initial shaping
(5) advanced thinning and final shaping
(6) grinding

These six stages of reduction are discussed below, followed by my predictions for behaviour in each of the stages.

(1) The **selection of raw material** includes solving problems of variability in the raw material between available stone at a single source. The selection of the raw material is done on economic, on technical and/or on cultural criteria. In my research I investigated the technical criteria for selection of stone. I predicted that, if exchange took place, specific stone types would have been selected consistently and with care. My method was to survey and evaluate the rock outcrops at the quarries. I did this both where extraction took place and where raw material was available across the site. Selection of raw material is analysed in Chapter 6.

(2) **Extraction of the stone** is the first part of the production process which creates waste. The waste is composed of many angular pieces of stone of varying sizes, some of which are not selected for axe making. To study extraction I conducted experimental work with stone material from the quarries. The results of the experimental stone knapping was then compared with the archaeological debris found at the quarries. The knapping behaviour in this early stage of reduction was predicted to be directed towards the selection of suitable pieces for preform manufacture. Efficient behaviour at this point would be directed towards conserving the raw material extracted. This conservation would be achieved by minimising the waste from haphazard reduction. The conservation practices would make available more suitable sized stone for axes from the existing stock of raw material at the quarries.

Extraction is discussed in Chapters 6 and 7. In Chapter 6 the detachment from the bedrock or rock bed is discussed as part of the general analysis of quarry exploitation. In Chapter 7 extraction is analysed in terms of the preparation of stone for handling by the knapper before blocking out.

(3) **Blocking out** is considered as the first stage in the reduction of the stone. Knapping is carried out to reach a point where the stone for axe making can be held in the hand. The output of this stage is what Crabtree (1972, 27), Dickson (1981, 212) and Bradley (1975) describe as a 'blank'. The selected stone is established as being suitable for knapping, but there is material to be removed and the shape or final form of the artefact is not yet defined. In this stage the stone mass is removed by initial trimming of a block. Some pieces of detached waste stone can be identified by conventional flake signs. The characteristic artefacts found at this stage of reduction are expected to be massive flakes, thick and wide in relation to length. Typically these flakes have a length, width, thickness (LWT), in which the width is equal to length and the proportion of thickness to length or width is high enough for the stone to be an angular block of 100 x 100 x 50mm. The shape and dimensions given for these flakes (and those in the shaping and thinning stage) are derived from work done by Newcomer (1971) and Burton (1980) and are tested and adopted by Edmonds (1989). I discuss their relation to my experimental trials and excavation in Chapter 7. Anvil reduction may be appropriate at this step, although it can be used at other stages, particularly to overcome difficulty in knapping freehand. My expectations were that the blocking out stage is carried out with the objective of testing and finding any flaws or technological problems with knapping the particular block. The testing is done before much labour has been expended in making the axe. Efficient behaviour in relation to the control of cost is achieved by not continuing to knap if the block has to be abandoned because of flaws.

(4) The second stage of reduction is **shaping**. At this point mass from the faces of the blank is removed in shaping to a preform. A preform can be hand held and is the shape of the proposed end product, although more flaking and shaping is required (Crabtree 1972, 49). The removal of mass is done as a part of the symmetrical shaping of the axe. From this point the margins can be worked bifacially, without the knapping effort being embodied in a piece of stone which will not shape to symmetry. The characteristic flakes expected from this stage are broad, squat flakes which are thick in section. They typically have a LWT measure which is a relationship of the width being twice that of length and thickness as a high proportion of length of 50 x 100 x 20mm. The knapping actions in this stage continue the value-adding process initiated in the blocking out stage. My expectations were that given efficient behaviour, a low error rate in knapping would be achieved, because this would minimise the amount of mass that must be removed from the preform in the stages of reduction.

(5) In the third stage of reduction the preform is advanced and work entails **thinning and final shaping** of the preform. The characteristic flakes expected from this stage of reduction are thinning flakes. These long, thin flakes have a typical LWT measure with the flake length is twice that of the width and the proportion of thickness to the rest of the flake makes it thin of 100 x 50 x 10mm. Efficient behaviour is to minimise the error in knapping to thin the preform. In this late stage of reduction any errors will require difficult recovery knapping and may not be successful. As cost control, the advantage in not generating knapping errors is the efficient course of action.

(6) **Grinding** of shaped and thinned preforms is the last stage of reduction. This stage does not always occur. Many axes enter circulation and are used extensively, but they are not edge ground (see discussion in Chapter 7). My expectations were that where grinding of a preform does take place, then raw material requirements will mean this stage almost certainly takes place away from the quarry. The expectations and behaviour of the previous stages in reduction should result at this stage in a preform where the minimum amount of grinding will give the required shape and quality to the bevel edge (Dickson 1972; Harding 1987).

2.7.1 Value-adding in the reduction sequence

Value-adding can be traced through the general reduction sequence. In the hypothetical example presented above, value-adding was described through the stages of manufacture for the mythical product. Value-adding takes place at different stages of reduction, for example as advanced preforms or extracted blocks, in response to the structure of demand for the goods produced. Under these circumstances value-adding in the stages of the general reduction sequence can be interpreted as one of benefit to the producers, and to the user who demands the product.

The stages of (1) **selection** and (2) **extraction** offer value-adding to the transaction by, firstly, identifying stone suitable for axe making and secondly detaching this from the bedrock in a useable form. The value-adding to the producer is made possible by the demand from the users for stone of that quality, or stone of that particular origin. The alternative for the stone users is to locate suitable stone where there is no economic transaction involved in the procurement. The value of the stone at this point will often be reinforced by a regime of restricted access operated by the producers. After extraction, the stone can be passed from the producers to the users in an economic transaction, whereby the stone leaves the quarry in the possession of the users.

During the stages of (3) **blocking out**, (4) **shaping**, and (5) **thinning**, value-adding continues. There is a revenue increase from value-adding through these stages of reduction. The value-adding comes from the exercise of skill by the stoneworkers in manufacture of axes. The skill of the stoneworkers exists as an alternative to the users procuring the extracted stone from the producers and then the users working the stone into an axe.

Under these circumstances value-adding plays an important role in determining the point at which stone is transacted between the producer at the quarry, and the user who demands the supply in some agreed form.

2.7.2 Efficiency in the reduction sequence

Value-adding differs from efficiency in that the conversion of stone into an axe is a value-adding process, but this need not be carried out in an efficient manner. Additional revenue is sought from value-adding decisions, but the decision only gives a point along the reduction sequence to offer the good in a transaction with a potential user. Efficiency will reduce the cost of manufacture at the point of value-adding where there are appropriate axe making techniques and organisation in production available.

Less axe-making effort, or a reduced error rate will give more to offer in exchange, depending on the balance between the costs associated with the raw material available and labour effort. The high total cost of extraction from some quarries (such as with sheer faces of solid rock, in Petrequin and Petrequin 1993), should in an efficient technology result in more units of axe stone. In these circumstances there is an incentive to be more efficient in use of the extracted stone, and the control of error rates in axe production are important for efficiency.

At the beginning of the reduction process it is not known which axes will pass into the exchange system and which will be used locally. During the knapping process in the reduction sequence some axes will become unsuitable for further processing to exchange in a trade for gain situation and will become available for local use. To the extent that these axes now available for local use have been worked to this point, they will have been subject to knapping action designed to produce efficiency traits. In this respect they are no different to axes produced for exchanging in trade for gain. When the axe is no longer in the production trajectory of trade axes then efficient knapping behaviours will not be relevant. The axe for local distribution can be manufactured under one of several regimes, but there is no imperative to achieve efficient actions as in trade for gain.

My predictions for efficient behaviour in the individual stages of reduction are summarised as follows:

(1) In stage 1 the **selection** of one particular type of raw material gives control over the performance and quality in output of the stone to be used. This control comes from the stoneworkers' knowledge of the working properties of the stone, in that the material has been selected after trial and error for alternative stone sources.

(2) After the stone is selected, efficient **extraction** in stage 2 is expected to maximise the amount of raw material available for making axes. The number of pieces of stone available from the extracted material will vary with the efficiency of the stoneworker's behaviour at this point. Maximising the number of axe pieces available from any one extraction event will reduce wastage and the need to extract more stone. Measuring the degree of efficiency at this stage of reduction is not easy because of the nature of the activity. Extraction involves heavy reduction techniques for the raw material and in the subtractive process blocks of stone of suitable size are released from the mass. It is difficult to make an assessment of the number of axe pieces available from extraction because of the continuing process of subtraction, which leaves no evidence of the economy of stone extraction at this point (conjoins apart, see Leach 1984). A way in which predictions of maximising the use of available raw material can be evaluated is by calculating the amount of stone of suitable size which was discarded at the quarry. This procedure is discussed in Chapter 6.

(3) In the **blocking out** at stage 3 the selection of suitable pieces for axes will continue. Flaws and intractable raw material are expected to be encountered by the knapper at this stage. My prediction for efficient behaviour is that the faulty raw material will be eliminated at this point in the reduction sequence. If knapping problems are recognised at this early stage, then it is efficient to abandon work on the preform. The additional labour effort required in the later stages of reduction can be put into preforms which have the exchangeability associated with axes of symmetrical shape.

(4) The cost control device operating in stage 3 is expected to continue in stage 4 **shaping** and stage 5 **thinning**, although the problems which affect efficiency in axe production will be different. Efficient behaviour can be attained by achieving a low error rate in knapping, because this will minimise the amount of mass that must be removed from the preform in the stages of reduction.

(5) A low error rate maintained in stage 5 is expected to benefit the **grinding** process in stage 6. Grinding will be more efficient where knapping control gives few errors and as a result there are few unconformities in the stone. The previous stages in reduction should result at this stage in a preform where the minimum amount of grinding will give the required shape and quality to the bevel edge.

In summary, technological analysis and the reconstruction of reduction sequences describe how a raw material is converted into an end product. Of themselves the reduction sequences do not solve the problem of how to evaluate the organisation of economic behaviour in small-scale societies. The theory of value-adding allows us to evaluate the economic behaviour in relation to the technological feature of the reduction sequence. For example, my discussion does not specify whether manufacture should be concentrated at the quarry or completed away from the quarry. What technological and reduction sequence analysis do indicate for axe production is the stage of production reached at the quarry. In a situation where the output of the quarry is transacted as an economic exchange, the organisation of economic behaviour is evaluated through the theory of value-adding, and efficiency identified through the flaking features on stone.

2.8 The production trajectory for stone axes

The model of exchange discussed in the hypothetical example of a mythical good is in some ways a limited view of the behaviour. The model describes how stone is procured for axes at a quarry and the axe making takes place at the quarry to provide axes for an exchange system. The purpose of production at particular quarries may be making axes for an exchange system, but within this major objective there are a number of other outputs from axe-making activity. The subsidiary outputs may be a necessary, or an incidental consequence of axe making for exchange. I have suggested two subsidiary outputs in a production trajectory, (hammerstones and axes for local use) where axes made for an exchange system do not always result in preforms suitable for entry into the exchange path (see Figure 2.2).

In the context of distribution and an exchange system in Aboriginal Australia, the bifacial shaping of a mass of stone from a source such as a quarry should result in increased symmetry during the production trajectory (see Figure 2.1). The production trajectory describes the production and use-life of the stone axe from the point of selection of the stone at the beginning of axe manufacture to its rejuvenation during use as an axe. The result is the production of symmetrical stone axes with alternative end uses for the non-symmetrical stone.

The production trajectory includes the general reduction sequence I have described for stone axe making. The general reduction sequence has six stages from selection of the raw material to grinding the shaped preform. Beginning from the blocking out stage (stage 3) of preform-making symmetrical shaping of the axe can take place. The knapping actions of the axe-makers can result in a preform being shaped to symmetry at shaping (stage 4) or at the advanced stage of thinning (stage 5). The expectation of the knapping actions is for more axes to be symmetrically shaped in the later stages of reduction than earlier stages. This data has been recorded for the preforms from Gulgong and Warren and is presented in Chapter 7.

Figure 2.1 and Figure 2.2, show the production trajectory for axes made at quarries. The production trajectory in these two figures shows the several outcomes possible from knapping activity at the quarries, which includes different end uses for the worked stone. In this case the trajectory includes the general reduction sequence for axe making and predicts the direction and use-life of the axes when being manufactured and distributed. Where axes are being made for distribution and not for local use, symmetry will guide the knapping actions. The symmetrical shaping is predicted to increase the exchangeability of the axe. In the course of manufacture, some axe preforms will be symmetrically shaped and predicted to have a particular production trajectory and those not symmetrically shaped will have a different use life.

Figure 2.1 gives the output from the production trajectory as having one of three states of symmetry. The three states of symmetry possible in the production trajectory are: (A) symmetry attained in the stages of reduction; (B) symmetry lost, where there is damage away from symmetry; and (C) symmetry is possible but not attained through the stages of reduction.

Class (A) will yield an axe which can be put into use-life as an exchange good in an value-added transaction. Class (B) produces an axe which has been damaged in manufacture, such that its potential as an exchange good in an (economic) transaction is now limited to either, local distribution and use by the stone knappers and their group, or on-site use as a hammerstone. In use life an axe may be damaged so that it loses its symmetry and may be rejuvenated to regain the symmetry. This is done by reduction and regrinding (Hayden 1989), which is less likely at the quarry where other uses are possible, such as for hammerstones. Class (C) outputs have never been reduced to symmetrical form at any stage in manufacture. In the case of these axes, symmetry attainment is possible, but has not been attained. The exchangeability of these axes is now limited to local distribution, or they may be abandoned on site and enter another use-life, such as reworking or use as a hammerstone.

Symmetry is attainable at any stage of the reduction sequence, but will increase along the production trajectory of the reduction sequence (see Figure 2.1). In the subtractive process of reduction for axe making symmetry is a criterion for exchangeability, and in this situation successive stages of reduction will give increasing symmetry. As I have pointed out in the scheme of axe making at the quarries, symmetry is compatible with value-adding but not the same as value-adding. Value-adding works along stages of reduction, in that the increased cost associated with progressive stages of reduction will be incurred for the gain in increased revenue from exchange. Symmetry also works along the stages of reduction. All other things being equal there will be a greater degree of symmetry, and it will occur more frequently in the later stages of reduction than earlier stages.

In my scheme of axe making at the quarries, exchangeability needs symmetry and this will favour exchange in the late stage of reduction. But logically (and probably temporally) exchangeability precedes a distribution system in which axes are made by efficient means and offered on the basis of economic value-adding. To offer axes made efficiently in cost terms and giving value-adding to the production process there must be a system of axe distribution, into which to introduce the axes made under these conditions.

Where symmetry of the preform is lost in the knapping process, or symmetry is possible, but the knapping in the reduction sequence did not give this symmetry, then there are two directions for the preforms. Figure 2.2 presents the outcomes from the behaviour in the reduction sequence. These subsidiary outputs are where case (2) axes enter into local use, but not as part of the wider exchange system, and in a particular case of preforms in local use, where they are recycled on the quarry and used as hammerstones in case (3). The treatment of axe preforms in these two cases is based on the state of symmetry to which they are reduced. On the basis of symmetry a decision is made about the trajectory of the worked stone.

In Table 2.1, the output of the production trajectory is classified by the three states of symmetry I have described for axes in the reduction sequence (see Figure 2.1). The purpose of the reduction is to produce axe preforms where symmetry is attained (A). This symmetry in axe shape (A) gives a product used as an axe in an exchange transaction. This output from the production trajectory is described in Figure 2.2 as (1) 'axe into exchange system'. The output of the production trajectory where symmetry is not attainable does not go into the exchange system. Symmetry is lost because of damage through knapping actions in the stages of the reduction sequence. In the state of symmetry which I have classified as lost and therefore not attainable, the preform axes will go into either (2), which is local use as an axe, or (3) as a hammerstone. The output of the production trajectory where symmetry is possible but not attained (C), results not from damage to the preform in axe making stages, but from inadequate reduction. The knapping of an axe preform did not result in a symmetrical axe, but it was not damaged in reduction. The trajectory from this state of symmetry will be into one of three cases as either, (2) local use as an axe, but not part of the exchange system, or (3) as a hammerstone at the quarry, or to be (4) reworked to symmetry for exchange. This last trajectory is possible because the preform has not lost symmetry by damage in knapping, and follows a recycling path like hammerstones.

In Table 2.2, the output of the production trajectory is classified by the distribution or end use of the preforms made at the quarry. This table shows from what state of symmetry the outputs of the production trajectory in Table 2.1 are drawn. Axes entering into the exchange system, which I have described as case (1) will be (A) symmetrically shaped. My scheme for the full production trajectory allows for the situation where preforms which do not (C) attain symmetry in the reduction sequence can be reworked to symmetry and then passed into the exchange system (4). This situation is probably a minor case for those preforms where symmetry is not attained, but is important in the full scheme of the production trajectory (see Figure 2.2). The importance lies in the general treatment of axes in states of symmetry through axe making stages and use-life. Where axes in use-life are not symmetrical, they may be rejuvenated to give symmetry (C). The rejuvenation will involve flaking and grinding to give a ground bevel edge. Where symmetry is not attained (C) at the quarry, entry into local use, may lead to rejuvenation in use-life, because this is one of the paths for axe preforms in a state where symmetry is not attained. The other trajectory for axes in state (C) is as hammerstones.

Table 2.2, shows the source of case (2) which are local use axes, as from the state of symmetry (B) where symmetry is lost and (C) symmetry is not attained. The source of case (3) hammerstones comes from the same states of symmetry as those for axes in local use. The distribution paths of cases (2) and (3) are different. The difference between them has an effect on their archaeological visibility. Hammerstones stay on the quarry and so should be identifiable in the flaked debris of sites, whereas locally used axes are distributed from the quarry and are more difficult to locate.

2.9 Conclusion on control in production and distribution of axes

My expectations about value-adding transactions and symmetry are related to distribution systems and procurement patterns for axes. The quarries are connected to distribution systems in one of two ways: either, where the quarry is part of a distribution system organised as trade for gain, which may be regional or long distance in the way it appears as a network; or, where the quarry is part of a local distribution or procurement and not based on trade for gain. In this Chapter I have evaluated the factors in stone working and organisation of production to give control over efficiency in relation to value-adding, and of symmetry in relation to exchangeability. My evaluation has shown that value-adding is not the same as efficiency, although the two should be compatible and both exist where my economic model of transactions operates in axe-making and distribution.

Value-adding theory determines at which point in axe making the transaction takes place. To that extent it is the rationale for the transaction as an economic action. In a situation where the output of the quarry is transacted as an economic exchange, the organisation of economic behaviour is evaluated through value-adding theory.

Efficiency is the quality of the behaviour prior to the transaction and requires knapping control within the stages of reduction. My expectation is for efficient behaviour to be registered by differences in control over knapping and is recognised from flakes in the debris of axe making. In theory asymmetrical axes can be made efficiently, but there must be a reason for the non-symmetrical shape, such as exists with exchangeability for symmetrical axes. Symmetrical axes can be made inefficiently and still be good for exchange.

Symmetry is the criterion of exchangeability for axes, and requires knapping control in axe making. The production trajectory shows the influence of symmetry in production and distribution. My expectation is for symmetry in shaped axes to give exchangeability to the product.

The implications for testing the economic model of axe making at the quarries is in the difference between exchangeability and value-adding on one hand, and symmetry and efficiency on the other hand. Symmetry can exist and axes can be exchangeable without it being an economic transaction. So, quarries with symmetrical axes, but without efficient production practices and processes may be present in the archaeological record. This situation may exist as a precondition to more efficient quarrrying and axe production, in which symmetry is the guiding feature of an axe in exchange. Where the economic model of exchange applies value-adding will be the basis of distribution for the axes. Where axe stone may be available to and demanded by one group as extracted and tested material, in another circumstance the axe stone may be transacted at a different stage in the reduction sequence. The process of value-adding will require the producer to decide at which stage in the reduction sequence to engage in an economic transaction with a potential user. The advantage to the producer lies in adding value to the stone into the later stages of reduction where the rewards in exchange are greater. In rational (marginalist) economic terms the revenue must exceed (or at least equal) the additional costs in successive stages of reduction.

Within the stages of reduction followed in axe manufacture, cost-control will be a factor in any system where axes are exchanged as an economic transaction. Cost-control will operate through efficient knapping behaviour in the stages of reduction. The efficient behaviour in axe making is not to determine its form or design, that is as a symmetrical axe for exchange. The effect of efficient behaviour as cost-control is to increase revenue to the producers of axes, and to stimulate the production of axes for exchange.

There are two possible outcomes from my study of the value-adding economic transactions model of efficient production and these are stated below:
Either (1) the quarries produced axes under conditions of value-adding economic transactions if both symmetry and efficiency of production are present.
Or, (2) the quarries did not make axes under conditions of value-added economic transactions, that is if both symmetry and efficiency are not present.

I recognised three possible reasons why axes are produced at quarries.

(1) For local distribution and use, where the axes are not exchanged.
(2) For wider distribution as an exchanged good, but without efficient production at the quarry.
(3) For wider distribution from an efficiency-based manufacturing process and traded for gain. Both symmetry and efficiency in production must be present for trade for gain to be the basis of goods in this distribution.
Focussing on (2) and (3) I have constructed methods for recognising these two reasons at two quarry sites (Gulgong; and Warren) for which distribution of axes was known from previous studies (see McBryde 1986; Binns and McBryde 1972).

If the hypotheses are falsified then there are two possible reasons:
(i) the underlying model (that is the general case) is flawed; or
(ii) the particular case did not support the model,but potentially another one could.

The following Chapters will build up an evaluation of the production and distribution of axes at Warren and Gulgong as a value-added economic transaction in which the efficient actions are central and symmetry guides the exchange prospects of the axes. I return to the evaluation of outcomes in Chapter 9.

CHAPTER 3

Stone axe distribution and quarry sources in east Australia

3.1 Stone axe quarries and exchange in Aboriginal prehistory

In Chapter 2 I developed the theoretical framework of production trajectories for axes. This framework allows me to evaluate the evidence found at quarries in terms of the patterns of distribution and exchange of axes. In this Chapter I move from the theoretical framework of axe making and distribution systems to look at the application of this theory to axe distribution in East Australia and the broad features of the quarries where axes are made. The Chapter discusses the distribution of axes and the location of axe quarries, in conjunction with other relevant archaeological data and sites in east Australia. To do this I have divided the Chapter into two main sections: first, an evaluation of axe quarries in the landscape and distribution system of east Australia; and second, discussion of the distribution of axes in the regional system of east Australia.

The 'axes' I refer to and which (as the products of quarries) form the basis of ths study have been described by McBryde (Binns and McBryde 1972) as 'ground-edge artefacts'. This description of the study material gave the distinguishing trait of what are often called 'axeheads' as stone with the property of being ground on the edge. This edge is generally seen as the cutting edge of an impact tool, but in using 'ground-edge' as the distinguishing property of the material McBryde does not question the function of these artefacts. In this study, I am interested in the products of hard rock quarries, both in their potential uniformity and their diversity. For this reason I recast the description of an 'axe' to include products which are not ground edged.

Davidson suggests handaxes 'are recognised as stone artefacts from which flakes have been removed from both edges' (Davidson and Noble 1990, 384). The use of this description enables me to look at products from the quarries in relation to their potential to circulate and enter into use-life. A problem raised by the use of this description as a definition is in the distinction between axeheads and bifaces. Crabtree describes a biface as an 'artefact bearing flake scars on both faces' (Crabtree 1972, 16), although not necessarily from both edges. The description is similar to that of a handaxe in that flakes are removed from two points, either edges or faces.

Flakes struck from a core may be shaped by bifacial or unifacial flaking and not result in an artefact recognisable as an axehead. The problem is that the size and weight of the artefact may be too small to be considered an axe or axehead. I have recognised the problem in this study of quarry products by looking at the bifacial and unifacial products as wedging and impact artefacts with a minimum weight of 100gm. The weight is probably low in relation to that of most axes. Most axes at the Australian Museum are above 230gm in weight.

These stone artefacts shaped on two edges, are often flaked on two faces and may be ground on their bevel edge. When these 'axes' as axeheads are ground on the edge they may be (are sometimes) hafted in a handle (McBryde's 'hafted stone hatchet'), or they may be bifacially flaked but not ground-edged.

When stone artefacts are hafted with the cutting edge parallel to the length they are often referred to as 'axes'. At this point they may be distinguished from 'adzes' where the setting is with the cutting edge at right angles to the 'haft' handle. When the stone artefact is removed from the haft, the 'axe' may be described as an 'axehead'. Axeheads may be set in handles or they may be slipped from the haft. These stone artefacts may be possessed in the material culture, both with a handle and unhafted. Axeheads out of hafts are like choppers, which are usually unground, that is they have what Dickson (1981, 213) calls a 'sharp raw edge'. All of these stone artefacts have a source, sometimes a quarry, and are manufactured through a production trajectory and distributed into a use-life.

I have chosen 'axe' as the best term for the product as they leave the quarry, and recognise that these will mostly appear in collections as the 'ground-edge artefacts' described by McBryde (Binns and McBryde 1972). These 'axes' are also 'axe-heads' in some terms, and may not always be ground on the edge when distributed. With my definition the 'axe' can be recognised in the production trajectory, where the axe is described with block, blank and preform stages in manufacture. These stages of reduction are discussed in Chapter 7.

Axes from known sources are used in evaluating distribution patterns in which axes have a life-cycle of consumption as part of an exchange system. The type of axes in distribution and nature of quarry exploitation in east Australia is considered in detail for areas around the quarries at Gulgong and at Warren. For the wider distribution of axes in east Australia, I use McBryde's studies on dispersal from sourced axe quarries as the basis of discussion.

To establish the suitability of the quarries at Gulgong and Warren for the tests I want to make on symmetry in the exchange of axes, and decisions on value-adding and efficiency in axe making, I have reviewed current information about quarries in east and south-east Australia. The distribution of axes from sources was studied in comparison with their locations and tribal areas. The suitability of Gulgong and Warren is supported by a more detailed study of axes from the areas around these quarries which are known in collections, particularly the Australian Museum. I discuss Aboriginal sites in the local environment around both Gulgong and Warren, and do this in relation to the quarries and the potential for them to be involved in exchange.

Before discussing the quarries and axe dispersal associated with some of these quarries I review the context in which axes and quarries are found in Australia, and how they contrast with those in other parts. The broad review is done before narrowing the focus of the study in Chapters 4 to 8 to the two quarries at Gulgong and Warren where axes are made. To do this I discuss: (1) the antiquity of edge-grinding axes in comparison to the late Holocene spread of interaction and ceremony; and (2) the size and types of axe quarries in relation to the dispersal of axes from their sources.

(1) Antiquity of axes in Australia. Ground stone axes have some antiquity in Australia and Melanesia. Dates of more than 26K years have been recorded for the Kosipe material (White *et al.* 1970) in New Guinea. In Australia there are dates of more than 27K at Widjingarri in the north-west (O'Connor 1989) and more than 30K years in south-est Cape York (Morwood and Tresize 1989; Morwood and Hobbs 1995). Hayden (1989) suggests these early ground edge axes are only to be found in the north of Australia and Melanesia.

The Pleistocene use of ground edge axes has not been accompanied by evidence of quarrying for the axe stone. Conversely, quarry studies have not led to Peistocene dates. The petrological work of McBryde in grouping axes to their sources has resulted in some axes having dated contexts (Binns and McBryde 1972). Late Holocene dates of 3K to 4K years BP are known from axes in archaeological contexts at Seelands rock shelter on the north coast of NSW (Binns and McBryde 1972, 79), at Graman on the Northern Tablelands (McBryde 1968, 85) and Black Range (Coutts and Witter 1977, 69). One of the axes from an excavation at Graman is sourced to the quarry at Moore Creek (group 2B) on the Northern Tablelands and was dated to nearly 4K years BP (c1800 BC see Binns and McBryde 1972, 79; Boot 1990). The recent date of systematic axe exchange from quarry sources may be related to increased group interactions, such as the Late Holocene ceremonial gatherings at places like Mootwingee (Witter 1992a). Davidson, *et al* (1992) showed that axe distributions from quarries at Mount Isa, Mount William, Moore Creek and Gulgong almost overlap at Mootwingee.

(2) Organisation of production at quarries. The way in which axe making is organised at a quarry will depend on the nature of production and distribution. Some systems will transport extracted material to a workshop where production will take place. Other circumstances will see much of the production process taking place at the site of extraction (Ericson and Purdy 1984; Cleghorn 1986; Nelson 1987; Ataman and Botkin 1991; Hayden 1987). Axes can be made from quarried outcrops of stone, or from loose cobbles and banks of river pebbles found across the landscape. Holmes (1894a) describes ancient banks of cobbles and pebbles being used for tool stone in North America. With the large range of possibilities, it is then a question of understanding the process of selection and extraction that is peculiar to each quarry (Jones 1984; Leach and Witter 1987; McCoy 1990; Tanudirjo 1991). The method of extraction and organisation of production has to be understood from inquiry at the particular quarry and cannot be assumed to take one form or another.

The organisation of production in quarries used was underpinned by a particular view of extraction held by Australian Aborigines. As points of extraction, quarries are surface sources where the activity takes place on a surface that is open to the sky above. The surface activity and any sub-surface activity at Australian stone tool quarries seems to follow this pattern. As well as Gulgong, the hard rock axe quarries at Mount William (McBryde 1984), Moore Creek (McCarthy 1941a; Binns and McBryde 1972), Moondarra (Hiscock 1988a; 1994), and Blechington Park (Knight 1993) are all surface procurement sites. Any surface activity can result in sub-surface features, for example quarrying for stone results in the shallow circular pits seen at Moore Creek (McBryde 1991) and Mount William (McBryde 1984). These pits can be extended deeper in the search for suitable stone, as I have observed in the grindstone quarry at Yambacoona near Brewarrina, but the result is always to lower or invert the profile of the working surface.

The type profiles classified by Hiscock and Mitchell (1990; 1993) for stone quarries in east Australia are described as either excavated or as surficial. Moondarra, Moore Creek and Mount William are coded as excavated, and Lowes Mount and Ngilipitji as surficial. In some ways the classification is artificial in that the description does not describe a conceptual boundary or pattern of activity that will always distinguish excavated and surficial quarries. A surficial quarry can become excavated where the surface quarry is a precursor to excavation. A much more important distinction seems to be between surface extraction and mining by shafts and galleries.

Similar patterns can be observed in the hard rock quarries of Europe and North America (Purdy 1984). Rock faces may be exploited and extracted with the surface being hollowed and deepened (Edmonds 1989; Le Roux 1971; Houlder 1961; Elston 1991). The extraction does not involve shafts or galleries, unlike with the extraction of stone in Papua New Guinea (Burton 1984) and the getting of flint in Europe (Bosch 1979; Sieveking and Newcomer 1987). Here shafts and galleries are used for the extraction of stone.

Burton (1984b) describes the quarrying of stone at one of several stone axe sources in highland New Guinea (Vial 1940; Chappell 1966). The tribal group associated with the quarry organised the reopening and exploitation of the shafts in an operation lasting several months. In the excavation operation props were used to extend the shafts, following the outcrop of stone favoured for brideprice axes (Burton 1984).

In the European Neolithic, farming increased the demand for flint tools (Welinder and Griffin 1984). These flint tools could be procured from surface sources and loose nodules at many places (Smolla 1987; Mercer 1987). But in Europe subsurface exploitation was used for flint procurement (Bosch 1979). The mining by shafts and galleries was deep underground and is known from eight places in the south of England and in the west and north of Europe (Bradley and Edmonds 1993). In California there is evidence of Native American use of mining to obtain ochre, or cinnabar red paint and flint for tools (Heizer and Whipple 1971; Heizer and Treganza 1971). The mines had tunnels and shafts running underground, made to exploit the resource from the surface into a mine.

The conditions of procurement and the concepts of extraction described in mining in Neolithic Europe and recent traditional procurement practices in highland Papua New Guinea contrast with stone procurement in Aboriginal Australia. But exceptions to the idea of the exploitation of quarries as surface sources in Australia are found. The ochre mine at Wilgie Mia and the Koonalda cave flint source are exceptions to the general rule that Australian Aboriginal stone procurement was not subsurface mining (Mulvaney 1975). The significance of this for the approach to procurement at quarries is that technical facilities and organisation of production not associated with surface exploitation are required. There is ethnographic evidence for the use of wooden scaffolds in the Wilgie Mia ochre mine (Mulvaney 1975).

In summary, there is no established antiquity for edge ground axes, when compared to quarrying for axe stone in Australia, although the increased group interaction in the Late Holocene suggests the use of quarries for axe stone in this later period. Quarrying for stone in Australia is a surface activity from an outcrop of suitable rock. Whether the surface area of the quarries is a guide to the size and output potential of the quarries is discussed in section 3.3.

3.2 Stone axe quarries in New South Wales

An axe quarry is a source of stone used for the making of axes and will contain the debris of stone extraction and possibly manufacture, using the same type of stone. In my analysis and classification of stone quarries, I have identified and focussed on stone axe quarries from the outset. This approach differs from that of Hiscock and Mitchell (1990), who do not distinguish between axe quarries and sources of stone used for other purposes.

The interest in the sources for axeheads is related to their rock mechanics. Overwhelmingly quarry sources for axes are hard rock materials in the basalt or metabasalt range, with many metamorphosed rocks used. Rarely occurring and in some ways completely different are the sources with a high silica content. The silica makes them more brittle than the hard rock used for the high impact tool. The reason for the occurrences of high silica stone, such as quartzite, in axemaking is uncertain and possibly significant. Rock outcrop axe quarry sources are overwhelmingly hard rock high impact stone in the basalt or metamorphosed range of material. Gulgong and Moore Creek are metamorphosed hard rocks that do not flake on impact. Warren is an unusual material and more like the flakeable and rather brittle silica sources, such as quartzite. But exceptions do exist and in Europe flint handaxes are made and used extensively, even though brittle (Sieveking and Newcomer 1987).

The 17 stone axe quarries known by name and location in NSW are given in Table 3.1 and those in the area of NSW covered by the map (a total of 13) are shown in Figure 3.1. The National Parks Wildlife Service in NSW do not record axe quarries separately from all other stone quarries. I have reconstructed the probable number of axe quarries in NSW by using the summary data from the NPWS site register in Hiscock and Mitchell (1990, Table 4.11) and the axe quarries known from McBryde's work (Binns and McBryde 1972; McBryde 1978; McBryde 1986). Axe reduction material is recorded on the site register from 18 sites, and the type of rock being reduced was known for 12 quarries. There is a balance of 6 axe reduction sites not accounted for by the quarries with known material type. Matching these 12 quarries with known rock types from McBryde's work, leaves 5 axe quarries of rock types which are known but not included in the site register. If reduction material at a site is the criterion for identification of an axe quarry in the NPWS recording system and in Hiscock & Mitchell (1990), then I calculate there are 23 axe quarries recorded in NSW. The estimate of 23 axe quarries is found from the 12 known rock types, plus 5 additional sites of known raw material and the balance of 6 reduction sites. The unidentified axe quarries could be small quarries as isolated outcrops, found in ad hoc surveys. Most are basalt and this is the most common field description of a hard rock suitable for axes found in Australia.

Basalt may be a convenient term for any fine-grained igneous rock found in small outcrops over parts of Australia. Examples of this type of outcrop are found in contract reports. At Tallawang, a basalt outcrop used for axes was described by Witter (1988). The existence of other unrecorded small outcrops across the Australian landscape must be a high probability. Binns and McBryde (1972, 52) describe some of their ungrouped axes, greywackes, metabasalts and basalts as occurring in small outcrops all over east Australia in the Central Complex geological formation. For example, an axe (McBryde #22) of greywacke from Walcha-Yarrowitch could have come from the nearby Tia Metamorphic Complex, but it is not the laminated amphibolite found at Tia axe quarry, nor the andesitic greywacke found at Moore Creek.

Compare this with the larger procurement quarries, like Moore Creek, which would be few in number but likely to be known. Location saved them in many cases as they are often on hilltops and slopes, and they would be likely to survive in the archaeological record. Modern quarries would use stone across the same range of properties as Australian Aboriginal stone axe makers. For example, at Mount Foster part of the quartz feldspar porphyry outcrop forming the source of stone for axes is used for road gravel. Surface quarries for stone axes and their traces of extraction and production may have been obliterated in the modern extraction and production process. This situation is found with the hard rock axe quarries in Britain. For example, the axe quarry of Graig Lywyd in North Wales is the source of petrological group VII axes, but the manufacturing debris has been destroyed by modern quarry activity (Warren 1922, in Edmonds 1989). Where now destroyed Australian Aboriginal quarries were located is difficult to know but certainly the early settlers exploited ready sources of stone, for use on roadways, across creeks and in aggregate bases for building structures. The introduction of machinery and the deep cutting of quarry sources might have destroyed the evidence of Aboriginal stone procurement.

3.3 Size and scale of quarries

The size of a quarry is one of the overall attributes that may be compared with other quarry sites. It is the motive and means for exchange, or reciprocity that is being sought in the question of size. The system of production and exchange is what is tied into the distributed object. This feature of quarry sites can be influential in the importance of a particular resource. For example, the size and extent of the Melos obsidian quarries were commented upon by early researchers who were working in the early part of the century (Torrence 1982; 1986). These researchers (Bosanquet 1904 in Torrence 1986; Mackenzie 1904 in Torrence 1986) connected the size of the exploited resource and the quantity of waste material to the idea of commercial trading activity (and restriction of access) in the Mediterranean. The output of quarries in relation to their size by surface area has not been investigated in Australia.

Size is another way of looking at output, that is, production at the quarries. Much of the output from a quarry is known from the production debris, as the distributed axes are not often identified. The situation requires a means for getting at output through volume, where depth of deposit as well as surface area is known, and quantity through the counting and analysis of stone categories.

The size in terms of output of a quarry is not always accessible, but some means of measuring different sizes of stone resources and their usage is needed. Surface area is the most accessible measure from the recorded information on quarries. From this some judgement will have to be used on the relevant features, such as depth, density and the technological aspects of the debris, to adjust size to an output statement. It is this sort of spatial information from quarries that enabled Torrence (1982, 212) to estimate the quantities of debris at Melos and for Fladmark (1984) to do the same at an obsidian source in North America. The results are in millions of stone pieces, with 50 million and 31 million calculated by Torrence for two sites and 48 million estimated by Fladmark. These quarries are large, with a high proportion of small flakes. Axe quarries in east Australia are not so big, although some contain a large number of broken stones. For example, Mount Bowen in NSW is reported to consist of an entire mountain side of broken stone (Witter, personal communication 1994).

My approach to their implied importance in distribution systems is to estimate the size of axe quarries in east Australia and rank them in order of magnitude. The point is to place the quarries at Gulgong and Warren on a scale in relation to the other quarries. This can be done on the basis of their surface area, depth and density of deposit, and degree of utilisation possible from the stone source. The problems in this calculation are not only in the availability of information by which to make uniform measurement between quarries. There is also the different characters of the quarries at

Gulgong and Warren to consider. The surface area of the quarry at Gulgong is associated with a depth and density over a limited and fairly well defined area. Contrast this with the sources at Warren, where the Mounts have no depth of deposit and material density is low. Under these circumstances comparison between sources with different characteristics is likely to require judgement about the relevant factors.

The size of quarries is given in Table 3.2. This is given in square metres of surface for the identified axe quarries in the estimate of quarry points in east Australia. Not all known axe quarries can be measured in this way, but a representative sample is given including the important quarries for this discussion of production and distribution.

At Warren the three Mounts carry extensive signs of stone tool procurement. The material is plentiful at the source, but appears only as a limited distribution of edge-ground artefacts. So the large quarry surfaces at the Warren Mounts exceed the surface size of Gulgong, yet have no depth and appear to be low output resources. Surface size is not the key to size as output. Surface size will be important, given the often tight selection and extraction criteria applied by the Aboriginal stone procurers and axemakers in prehistory. The surface will be important for size calculation and evaluation because the second size dimension is depth.

Extraction at the axe quarries is not deep. I base this observation on the collected data for quarry dimensions and my own excavation. Less than one metre is usual, although stone extraction in Australia can be much deeper. For example, the pits I observed from extraction of grinding slab stone at Yambacoona are much deeper than one metre. In general, the shallow expectation for the depth of procurement in Australia will cause large quarries based on a single homogeneous geological unit to cover a large surface area. I suggest the size of Moore Creek at 1500 square metres as being recognisable as a large quarry.

The quarry complexes at Mount William in SE Victoria (McBryde 1984), and Blechington Park (Knight 1993) and Moondarra (Hiscock 1988a; 1994) in NW Queensland are large. They are larger than Moore Creek and cover an extensive surface area with some depth of deposit. Inevitably these calculations will include reduction areas for production of axe preforms. This stage of reduction will be after the point of extraction that distinguishes the quarry and its debris from the reduction areas. The surface area size calculations do not allow for axe reduction sites which are recorded, but found away from the quarry or not associated with extraction (Hiscock and Mitchell 1990). The quarry may be without reduction sites or may incorporate them in the surface, as would be expected for Gulgong and Moore Creek. Gulgong measures less than Moore Creek on this calculation of size by surface area, where this size estimate is modified by knowledge of the depth of deposit. This method of assessing size and output activity does not take account of variation in the exploitation rate of raw material from the different quarries. Flawed and unsuitable sections of stone can occur in the selected material. Techniques of knapping can result in differences in waste from production of the same unit. But the overall effect of these factors may be negligible in comparison with the dominant factor of size by surface area.

In conclusion, the discussion of size in quarries suggests that surface size is not the key to size as output, nor is surface size the key to the extent of distribution. Some small axe quarries in east Australia have material widely distributed. Under these circumstances the study of two quarry systems in east Australia, one at Warren and the other at Gulgong need not be predetermined in outcome. The extensive quarry system at the Warren Mounts is not necessarily a factor that will give it dominance in the distribution of axes in east Australia. By the same reasoning, the smaller quarry at Gulgong may be significant in the distribution of axes because of the nature of production at the quarries and the organisation of distribution from the quarries.

3.4 Distribution of stone axes in south-east Australia

Figure 3.2 shows the direction and extent of stone axe dispersal from the quarries in the south-east of Australia. The map is from McBryde (1986) with additions from Connah, Davidson and Rowlands (1977) as a conjection from Binns and McBryde 1972). The top part of the map is the quarries of New England, Central Tablelands and Western District of NSW and shows dispersal over long distances in a westerly direction from the quarries at Moore Creek and at Gulgong. Figure 3.1 shows this westward dispersal of axes from quarries using the axes in McBryde's initial study (Binns and McBryde 1972) with additions of axe dispersals from Gulgong and Warren (McBryde 1984).

The location of axe quarries and distribution of axes is shown on the map (Figure 3.1) in relation to the tribal areas. Tribal affiliations or language groups may be important in the pattern of dispersal from sources of axe stone (McBryde 1986). My research does not concern the relations between tribal groups or the importance of language barriers. Some division of the landscape on pre-colonial cultural grounds is valuable for appreciating possible social and political aspects of the distance travelled by the axes from their source. In the area covered by the map, the dispersal of stone axes from some sources (like Gulgong) can move long distances across the same tribal area.

The movement of axes across the landscape in tribal areas may require different arrangements from the movement across boundaries between groups (see Connah, Davidson and Rowlands 1977).

What is noticeable is the concentration of axes close to the quarry of origin (Figure 3.1). For the Moore Creek axe stones most of the collections greater than five are close to the quarry (that is within 100 kilometres). The few axes found further away from the quarry (greater than 100 kilometres) are in small collections of less than five. Dispersal of axes from the two hard rock quarries at Moore Creek and Gulgong extends west in direction, but the amount of axes found are not numerous or dense in concentration. The axes from the quarries at Graman, Salisbury Court and Tia are found in small numbers around their respective raw material sources. The only dispersal away from the quarries is towards Moore Creek quarry and a nearby area where axes from Gulgong and Moore Creek are also found. These axes from the quarries at Graman, Salisbury Court and Tia are not found at Wilcannia, where axes from Gulgong and Moore Creek are found.

If axes in dispersal are distributed through nodes or places where ceremonial exchange will involve the exchange of (amongst other things) axes, then there is the strong possibility of axes from different raw material sources being passed through the same node or exchange centre. The dispersal of the axes from their quarries along the west side of the Great Dividing Range is in a general north-south direction. This dispersal takes place within the distribution of axes from the quarries in the region, so that axes from Graman quarry are in the south and axes from Moore Creek quarry are in the north.

My evaluation of the dispersal from axe quarries in the east of the region (but on the west side of the dividing range), is that axes move north and south and extend to the west. A further evaluation of the pattern of dispersal in the axe groups and quarry products of the region is possible, by the addition of the other axe distributions from petrological groups described by Binns and McBryde (1972), and from the quarries at Warren and Tumut. Warren axes are found as edge ground and unground bifaces in an area around the quarries including the town of Warren and the Macquarie Marshes. A few are found on the Lower Macquarie River and some in the area between Narromine and Dubbo. The dispersal of Warren axes is limited to this area. They are not found at several hundred kilometres distance from the quarries and are not dispersed west along the river system towards Wilcannia. The axes from the quarry at Tumut have a distribution similar in surface area to that of axes from Graman (McBryde 1986). They are like Warren axes and are not dispersed over an extended area, nor do they incorporate into the Victorian axe distribution system.

The southern section of the map in Figure 3.2 is the Mount William and Mount Camel quarry complex and distribution system described by McBryde (1976 to 1986). The greenstone hornfels from Mount William, in particular travel 700 kilometres along the Murray-Darling Rivers, from what Davidson, Cook and Fischer (1992) referred to as a 'long transfer quarry'. They travel with repute (McBryde and Harrison 1981) from their place of origin 'in the Melbourne country' a long way from the quarries, probably via ceremonial exchange nodes at certain meeting places. Like quarries in north-east NSW some do not have a wide or extensive dispersal of axes. Quarries at Berrambool, Geelong, Jallukar, Baronga, and Howqua have axe distributions which are restricted to less than 100 kilometres around the sites.

I conclude from this review of distribution from the axe quarries in east Australia that the dispersal from Gulgong quarry can be contrasted with that of Warren, and that the contrast is based on the type of exchange in the distribution system. In most cases axes are concentrated close to their quarry source. This concentration suggests axes were not all part of an extensive or far reaching distribution system. The tribal areas and boundaries do not seem to determine the extent or direction of the axe distribution from source.

The axes from Warren are found in three tribal areas, two of which share boundaries where the quarries are located. But one area (Wongaibon) is large and the dispersal is not across the whole of these tribal areas. The distribution is local, and suggests the type of exchange is a distribution system based on regular contact between groups in the area, but not a production system based on value-adding decisions and efficiency in axe making. In contrast, some axes from Gulgong have an extensive dispersal, and the pattern suggests the type of exchange was organised with cost-reducing responses to axe making. The type of exchange in the distribution system fitted into the pattern of distribution established by the larger quarry at Moore Creek, and the wider and more extensive distribution from this source.

3.5 Distribution of stone axes in New South Wales

In the previous section I discussed the distribution of axes from the quarry system at Warren, and the eastern quarries of Gulgong and Moore Creek. The restricted dispersal of axes from Warren was contrasted with the extensive distribution of some from Gulgong and Moore Creek, and the concentration of their numbers around the quarries. I will now focus the discussion from the previous section on to the axes found in two places: (1) the Wilcannia area; and (2) between Gulgong and Moore Creek, centred on the axes sourced to quarries found around Currabubula.

In Figure 3.3, I have shown the axes in McBryde's study (Binns and McBryde 1972) from the Wilcannia area in the Western Division of NSW, and from the Currabubula area on the Liverpool Plains. The axes found in the Wilcannia area and from Currabubula are shown in the groups defined by McBryde. The purpose of selecting the two areas at Wilcannia and Currabubula is to compare the groups of axes found in the two areas. Some petrological groups are found at both Currabubula and Wilcannia. The relevant petrological groups are shown for the two areas in Figure 3.3 and in Table 3.3.

Table 3.3 shows that of the 13 groups and subgroups found at either Wilcannia or at Currabubula, there are 6 not found at one of the two locations. Three of the groups are not found at Wilcannia and three are not found at Currabubula. I will discuss these axe groups and McBryde's comments on them as part of my study of the westward dispersal of axes. The seven axe groups found at both Wilcannia and Currabubula have not all been sourced to their place of origin. The quarries at Gulgong (group 10) and at Moore Creek (subgroup 2B) produced axes found in the Wilcannia area and in Currabubula. These two sources are the only known quarries with axes at both Wilcannia and Currabubula.

Other axes in subgroups found at both places may have a common source. For example, McBryde (Binns and McBryde 1972, 34) describes the axes in group 5, including subgroup 5A, as having a 'distribution pattern resembling that of 2B axes'. The axes in subgroup 2A are found in the east and west of the distribution. McBryde (Binns and McBryde 1972, 20) describes the source as pebbles from the Baldwin type greywackes, which suggests a location in the east and possibly in the dividing range. The distribution pattern is from the New England Tablelands across the Liverpool Plains, west along the Darling River to Bourke and Wilcannia.

Other groups of axes found at both Wilcannia and Currabubula have no common source. For example, group 9 and subgroup 3B, are found in both areas and are widely distributed, but they cannot be identified as coming from a common source. In fact, McBryde recognises the possibility of these axes coming from more than one source. McBryde (Binns and McBryde 1972, 26) comments that the axe at Wilcannia may have come from rock outcrops north of Wilcannia. Witter (pers comm 1995) reports a recently found axe quarry and reduction sites at Tibooburra, north-west of Wilcannia.

The implications from this review of the distribution of axes in the groups and subgroups identified by McBryde is that the concentration of axes in the Wilcannia area of the Western Division indicates a distribution from the east to the west. Axes are concentrated in the east, but have an extensive dispersal to the west. The likelihood of trade or exchange systems being the mechanism of movement for the axes found in the west has been discussed by McBryde (Binns and McBryde 1972). This westward distribution of axes is supported by those found at Bourke, Brewarrina, Cobar and Dubbo. But of the 517 axes in McBryde's sample very few are found in the west. The Wilcannia area has 37 (12%) axes collected in the sample from a set of groups and subgroups of 308 (Table 3.3).

There is a concentration of axes in the Wilcannia area, and there is a similar concentration at Currabubula. The west has axes in groups not found in the east. This concentration is increased by the groups of axes from local sources. Wilcannia is on the Darling River and the lower Darling River is part of a distribution system where axes come from the sources at Mount William and Mount Camel in the south (Figure 3.2). Wilcannia is also connected to the Paroo River which joins the Darling River above Wilcannia. The Paroo River is part of a system of trade routes going into Coopers Creek and north-west Queensland (Horne and Aiston 1924; McCarthy 1939; Mulvaney 1975; McBryde 1987). The Cooper Creek tribes are reported to get stone axe heads from NSW (Howitt 1904, 717).

The Paroo River joins the Darling River where axes from many sources and directions are found, that is in the Wilcannia area. In this area, the Mootwingee ceremonial centre is at the intersection of multiple Dreaming tracks from all directions (Witter 1991). The existence of engraving sites suggests the area may have ceremonial significance, and the level of interaction between groups encourages variety in the items of material culture brought into the area. The collection of axes found in the area are from several sources and the situation suggests there was an exchange node in the distribution system. McBryde (1978, 364) describes ceremonial exchange centres at some distance from the quarry at Mount William. Mootwingee and the Mutawintji ceremonial area may have served this role in the Late Holocene (Witter 1992a; Davidson, *et al* . 1992).

If the axe distribution to Wilcannia is associated with trade routes and ceremonial centres in the area, then the collection of axes at Currabubula suggests an interaction area for groups of people from several directions. Mathews (1907) hypothesises the movement is one between north and south, and the dispersal of axes through the Moore Creek and Currabubula area supports this statement. The axe groups in the area are restricted in their distribution, but axes from Gulgong are found north of the quarry. The group 10 axes from Gulgong are found (going north) at Dunedoo (#503), Breeza (#345), Currabubula (#366 and #367) and Glen Innes (#474). From the axe distribution data, Currabubula could be an exchange node north-south and east-west.

In summary, the distribution of stone axes from McBryde's sample are concentrated in the east, with a dispersal north-south and a spread to the west. The only quarried axes from known sources at Currabubula in the east and at Wilcannia in the west are from Moore Creek and Gulgong. In the previous section I suggested the movement of axes over long distances may be an economic transaction. There are two factors in the development of this situation:

(1) The scarcity of stone sources in the west is a reason to favour the economic transactions argument. The scarcity of stone would induce production in the east, and in this circumstance the availability of stone in the Warren district would create an exception to the general scarcity in the west. A distribution system operating on scarcity would encourage axe making based on value-adding decisions and efficiency in manufacture and distribution.

(2) At Wilcannia (as at Currabubula) there was what appears to have been an exchange node. Exchange is an interaction based on groups and individuals. Because of this pattern of interaction, opportunities for development of exchange systems exist and some material advantage may be had by putting this on an economic basis of transactions. In these circumstances decisions based on value-adding and efficiency in production can develop among groups who attempt to expand their contacts with others and the output of axes.

3.6 Stone axes in the Gulgong and Warren areas

The fact that stone axes in the tribal areas around quarries such as Gulgong and Warren may not all come from the local quarries is central to this study, namely the study of axe making as a value-adding economic transaction. Knowledge of the volume of stone which has come from other places, as well as possible sources of this stone is as important as knowledge of distribution patterns of the axe stone. There are two reasons for this: first, because the propensity to trade-in axes from other places carried some indication of local scarcity; and second, because of the extent and direction of distribution systems as they affect the areas around the two axe quarries.

In the sample of 251 axes from the Australian Museum collection, 45% are from the tribal areas around Warren and 55% are from around Gulgong. Figure 3.4 shows the axes in the Museum collection located in the tribal areas described by Tindale (1974). Gulgong is the north part of the Wiradjuri area, with the area around Gulgong extending to the south part of Kamilaroi, and the Geawegal/Wonnarua area. Warren is in the Kawambarai area, and is joined by the north and east part of the Wongaibon area, and the Ngemba and Weilwan areas. The Warren area joins the Gulgong area along the north boundary of the Wiradjuri area.
The purpose of this map of the areas around Gulgong and Warren is to locate and enumerate the axes collected in the Australian Museum as they relate to the quarries at Gulgong and Warren. All of the axes known from Warren are included in this distribution map, but some of the axes sourced to Gulgong quarry (group 10 in Binns and McBryde 1972) are not on this map (Figure 3.1). Only six axes have been identified from the Gulgong quarry, and two of these were collected from Wilcannia which is 900 kms from the quarry source.

The stone at the Australian Museum is classified by the location of the place of collection. The integrity of the classification of axes in the collection cannot be resolved to discuss places and conditions of discard. The location given in Table 3.4 and shown on Figure 3.4, will represent the place of collection before being curated by the Australian Museum. I will discuss the axes from the area around Warren and from Gulgong. Warren presents a less widely distributed case than does Gulgong.

My data on axes from Warren was based on what is held in the Australian Museum as from 'Warren district' and the 'Lower Macquarie River'. These two location groups contain axes of quartz feldspar porphyry (QFP) from the Warren quarries, as well as other hard rock. Table 3.5 summarises the data on axes from the Warren district and the Lower Macquarie River. The Table gives the number of axes from the Warren quarries and others made on hard rock. Of the 77 axes in the Warren sample, 34 (44% of the total) are the distinctive quartz feldspar porphyry from the Warren quarries (see Figure 3.5). The other 43 axes are of hard rock material for which there is no one source established. These hard rock axes are likely to be from many different sources. The reason for many different stone sources is that the Warren district is on the silt plains of the Western Division, which is a place of very few stone outcrops. The variety of sources for stone is emphasised by the number of axes in the sample made on pebbles or cobbles.

The axes of hard rock material are classified as made on pebbles in the case of 25 (58%) of the sample (Figure 3.6). These pebble axes are all ground on the edge, which makes the majority (71%) of edge ground hard rock axes to be made on pebbles. The 25 pebble axes from the Warren district are 37% of the total pebble axes in the sample from the Museum collection.

The influence of the quarries at Warren is shown when the number of edge ground axes is compared with the number not edge ground. Most of the axes (53%) on Warren stone (QFP) are edge ground, but 47% are not. Compare this with the other hard rock axes found from the Warren area, where 81% are ground on the edge and only 19% are not ground (Figure 3.7). The majority of hard rock axes in the Warren area being edge ground suggests these axes from outside the region were traded-in. The quarries at Warren are the local source of raw material for axe stone and for cores for flaked tools. Axes made at Warren can be ground at the quarry site (Figure 3.8). The Little Mount quarry at Warren has many grinding grooves with signs of use, yet there are in distribution bifacially flaked preform axes with no grinding. Some of the specimens that have been found away from the quarry (near the Macquarie Marshes and towards Brewarrina) were unground. The situation suggests the quarries to be a source of stone with many different production trajectories, some of which do not require the bifacially flaked stone to be edge ground at the quarry.

The number of axes from the Gulgong area in the Australian Museum collection is given in Table 3.4. The 138 axes in the Australian Museum collection for the tribal areas around Gulgong contains four axes from Gulgong quarry. The wide area of axe collection for the Gulgong sample cannot be easily narrowed in the way the Warren sample has been treated. There are 28 axes in the Australian Museum collection of axes in the local area of Gulgong (Figure 3.9), but only two of these axes are from Gulgong quarry and appear close to the quarry, in the way axes from Warren quarries are found in the Warren district collection.

The axes in the Museum collection from around Gulgong are likely to be from many different sources. Of the 138 axes in the sample one out of three (33%) are made on cobbles (Figure 3.10). Most (90%) of the axes in the sample are edge ground, but 10% of the axes are not edge ground and these are found on quarried axes. The axes at Gulgong are more typical of those found in the regions of east Australia than the sample of axes from Warren, where the Museum collection is dominated by local axes from the Warren quarries.

In conclusion, different types of axes came into the areas around Gulgong and Warren, as pebbles and quarried stone, both ground and not ground. In terms of the economic model of transactions, the situation at Warren where half of the axes come from outside the region, suggests that the hard rock axes found in the area were traded-in to an area of scarcity. Gulgong has fewer local axes than is found at Warren, and the axes which are imported to the area are mostly and more often edge ground than at Warren. On this basis, the distribution system in the Gulgong area operated with more open trading than that found at Warren.

3.7 The quarries and stone axes in the landscape around Gulgong and Warren

The purpose of this section is to compare the distribution of axes from the known sources at Gulgong and Warren, rather than as in the previous section where all axes in the Australian Museum collection from around the Gulgong and Warren areas were discussed.

(1) Gulgong. A group of axes sampled by Binns and McBryde (1972) was identified as being from the same source. The identification was made by thin sectioning axes in the Australian Museum and private collections. Petrologically six axe heads were identified as actinolitic schist of the same material group (group 10). Then the axe quarry at Gulgong was recorded and the quarry workings and waste were linked with Binns and McBryde group 10 axes (McBryde 1986). The area around the hill site is 'Canadian Lead' where there was much prospecting activity in the gold rush era of the 1870's (Maxwell 1982). Yet the hillside shows no signs of damage or plunder from the nearby activity. The surface disturbance in the valley of the Cudgegong River running from Home Rule to Gulgong is extensive and close to the hill site of the quarry. The effect of the disturbance was to destroy the sites and other evidence of Aboriginal occupation which may have existed close to the quarry.

Gulgong is in the Central Tablelands of the NSW regional meteorological districts. Pearson (1981, 12) suggests the region of the Cudgegong Valley around the quarry at Gulgong is one conducive to both Aboriginal usage and European settlement. The area is a lower elevation than other parts of the Dividing Range, and the winters are less severe. In the last four thousand years it has been a well-watered area of mixed vegetation, with natural grasslands and hardwood trees.

I will discuss the archaeological resources around Gulgong, that is, axe quarries and other sites in the area. The evaluation of these sites is needed to give some context to my study of the two quarries, that is, how they fit into the pattern of Aboriginal life. My discussion in this section is in relation to the subsistence economy and ceremonial interactions of the people connected with the quarries. I put the quarries at Gulgong and Warren in a context with other nearby stone resources where similar or different practices may have taken place.

The Gulgong quarry is one of three axe quarries in the Upper Macquarie Valley, which is part of the Wiradjuri tribal area. The other two are Arthurville near Wellington and Lowes Mount near Oberon (see Figure 3.1). Lowes Mount axe quarry is a metavolcanic material of amphibole hornsfelses (Baker 1987) and Arthurville is a medium-grained andesitic greywacke. The Lowes Mount quarry has been studied by Baker (1987) and his results are discussed in Chapter 5. Arthurville axe quarry has a worked area 70m long, with flaking areas nearby (Pearson 1981). Neither Arthurville nor Lowes Mount has a recorded dispersal of axes to any distance from the quarry. There is a fourth quarry in the Wiradjuri tribal area at Tumut. Tumut is on the boundary of the Wiradjuri area (Tindale 1975), and has a limited dispersal of axes from around the source (McBryde 1986). The description of these four quarries does not include the possibility of many small quarries in the area. An example of one is near Gulgong at Tallawang, where one axe preform was recorded (Witter 1988). The surface area of the rock exposure where material can be extracted may be only a few square metres in the case of these small quarries, and there may be only a few knapping scatters.

Pearson (1981, 80) suggests there were three local Aboriginal groupings or clans in the Upper Macquarie. These are in the Wellington, Mudgee and Bathurst areas. Based on the idea of drainage catchment basins being important in forming cultural boundaries (Peterson, 1976), the clan territory boundaries are centred on three important resource regions. The Bathurst clan are associated with the Bathurst Plains; the group from the Mudgee and Rylestone areas with the Cudgegong River, and the Wellington clan with the Dubbo slopes and the Bell River valley. From this it appears the Mudgee clan would have had access to the quarry at Gulgong. Pearson (1981, 106) speculates that the location of the quarries in the area coincided with the territory of the three different Aboriginal clans. The groups were not unconnected, as they were all Wiradjuri and the ethnohistorical reports of the area suggest a close link between the Wellington and Mudgee groups (Pearson 1981, 83).

The territory of the Wiradjuri people is large covering 97,100 square kilometres, where the towns of Dubbo, Condobolin and Bathurst are now located. The Wiradjuri occupied the western slopes, plains and riverine areas and at the time of contact were dependent upon grass seed collection, hunting of large macropods and collection of smaller reptiles and rodents. The large tribal grouping and the many clans of the Wiradjuri were connected by a cycle of ceremonies which moved around the tribal area (Tindale 1976). Exchange interaction involving the Wiradjuri is also reported to have occurred on a wider basis than contacts between members of one tribal group. Trade routes for axes along the eastern grassland corridor pass through Wiradjuri country and are reported to link with axe quarries in Victoria (Mathews 1907, 37). Figure 3.2 shows the distribution of greenstone axes from Mount William and Mount Camel along the Murray-Darling River system towards Wiradjuri country. The interactions between people and exchange of goods took place at meetings for ceremony and trade between the Wiradjuri, Wongaibon, Kamilaroi, Ngemba, Kawambarai and Weilwon. Gulgong is in the Wiradjuri area and the axe quarries at Warren are on the boundary between Wongaibon and Kawambarai areas. Berndt (1946, 344) describes all these groups as being culturally affiliated.

In the Wiradjuri area there are areas of abundant stone, like Bathurst, and areas of no stone like Condobolin (Gresser 1962, 530). This situation offers research potential in the study of the dispersal patterns of stone tools from stone sources in the area to the sites in the stoneless area. The Wiradjuri tribal group covers a large area where variation in dispersal can be registered. Other sites in the area are open campsites, rock shelters, grinding grooves and art sites. These sites in the area are important because of their possible connection with axe making and axe use away from the quarries and this axe working was connected to other activities. Some of these may have ceremonial significance, as places of aggregation and meeting. Ericson (1981) points out that in any ceremonial situation it was likely that more than one activity was going on, and the exchange of goods was likely to be one of the activities.

There are 15 open sites recorded in the Gulgong-Tallawang region (Sullivan 1992), with their distribution largely determined by the archaeological contracts done for mining in the area. Axe finds in the area are mostly limited to the collection in the Australian Museum. But Pearson (1981) reports a group of 12 axes were found near a site at Sandy Creek, Goolma (see Figure 3.11). The source of axes gathered in one campsite would be valuable in terms of distance and direction of axes from source, and the stone working characteristics on the axes.

The Aboriginal occupation of the region has been given some temporal perspective by the archaeological field work and excavations done by Pearson (1981). Radiocarbon dates for his excavations at Botobolar and the Granites 1 and 2 rock shelters, give occupation from seven thousand years ago to two hundred years (1981, 145, 149). The results of Pearson's work are interesting for the production and distribution of axes in the area. At Botobolar rock shelter there are portable axe grinding grooves on the surface, and Pearson (1981, 142, 355) reports the finding of a flake from an edge ground axe.

The sandstone hills of the region have numerous rock shelters and axe grinding grooves. In Figure 3.11, I show the axe grinding grooves and stone arrangements in the Gulgong area covered by the 1:100,000 topographical map of Gulgong (sheet 8833). The sites are recorded from the NPWS site register. I have condensed this data for the axe grinding grooves to a marked area on the map of the Gulgong and Warren region in Figure 3.5. The 16 axe grinding grooves and 5 stone arrangements found on the Gulgong map all occurred in the northern part of the map (sheet 8833). The quarry at Gulgong is in the southern part of the map, with the grinding grooves between 20 and 40 kilometres away. The axe grinding grooves recorded are across the dividing range in a belt, with a cluster of seven axe grinding grooves in one area 500 metres above sea level, along with three stone arrangements.

At the sites I visited there were interesting features in the use of raw materials. In one site on the 'Winona' property of Mr and Mrs H. Seis the sandstone selected as suitable for axe grinding changes along the ledge into a coarser grain of the same sandstone. At this point the use of the ledge for axe grinding stops. All 60 grinding grooves at the site are in a finer grained sandstone surface. The criteria for suitability seemed to be operating clearly in the use of fine grain material from available stone. Discrimination in the selection of raw material is a feature of the nearby Gulgong axe quarry. Some of the stone used for axe grinding could be detached in thin slabs and used as portable grinding gear. Not all the grinding groove sites are near water. There are some grinding grooves where the suitable types of rock are exposed near running water and some at rock pools, such as Nagundi, where there is also a rock shelter. There are numerous rockshelters in these hills, and some further south, such as at Botobolar (Pearson 1981). Botobolar has pecked walls and is one of the few recorded ceremonial sites in the area.

I conclude from this discussion that, although there is a lack of campsites in the immediate area of Gulgong quarry, there are sites in the region not affected by gold prospecting in the nineenth century. The content and nature of the sites in the area around Gulgong have features important in evaluating the value-adding decisions made at the quarry. The production trajectory at the quarry does not extend to stage 6 of the reduction sequence, that is grinding. But grinding facilities are available in the nearby sandstone hills, and many grinding grooves have been recorded. At stage 5 of advanced thinning there is then a value-adding decision to be made about the production of axes. At Gulgong there can be further thinning of the preform at the quarry which would minimise the effort needed in grinding and finishing to attain a satisfactory quality of finish. The process would increase the certainty of successful transfer into the distribution system of an axe made for exchange. The situation at Gulgong can be compared with that of Warren, where preforms can be less finely finished, but more investment can be made in heavy grinding on site.

(2) Warren. The three Mounts at Warren were known in the early part of this century and a description was published by Towle (1939). Towle had visited the area and made a collection of preforms from the mounts. McBryde studied this collection at the Australian Museum in an evaluation of the potential of the Warren axe quarries and made aerial observation of the sites in 1980. This initial evaluation was not followed by fieldwork, although in 1986 Dan Witter visited the sites. Witter (1992b) noted the location of preforms at Mount Harris and Mount Foster and was able to test the raw material for stone working properties and suggest a reduction sequence for axe making.

The Mounts at Warren are Mount Harris, Mount Foster and Little Mount. This area of New South Wales was recorded by early explorers as occupied by many people. John Oxley sighted the mounts on an expedition down the Macquarie River in 1818 and recorded a group of eight Aboriginal women and twelve children at Mount Harris (Oxley 1820). In mid-summer there was a seasonal concentration of people at this section of the Macquarie River. This decrease in the water flow and the drying of the country around did not affect the Upper Macquarie, where there is more water in all the water courses (Pearson 1981, 68).

The Mounts have attracted interest from Europeans since the early days of settlement and their significance was recognised early on by the recording of the Aboriginal names for two of the mounts. Mount Foster is known as Narrabon and Little Mount is Eugolma. Towle (1939) suggests the sites have ceremonial significance. All three mounts are within sight of each other on a flat plain with the Macquarie River, Marra Creek and Bulgeraga Creek crossing in a general north to NW direction (see Figure 3.12). The two largest Mounts (Mount Harris and Mount Foster) are eight kilometres apart. Mount Harris is 1.8 kilometres long and Mount Foster is a series of hills which runs for 2.4 kilometres. The smallest mount is Little Mount, a kilometre across the river from Mount Harris. Little Mount is 650m at its longest point. The smallest mount is also the lowest in height, rising only 25 metres out of the plain. Mount Foster exceeds Mount Harris by rising 86 metres to 266m at the Telecom tower on the top, and Mount Harris rises 62 metres at the south end where there are some European graves. These Mounts are old igneous rock masses of quartz feldspar porphyry (QFP) (Adamson 1964; Pogson 1994) which rise out of a plain below the 180 metre contour at the base of the hills. The plain is flat in every direction, and the Mounts form a prominent feature of the landscape. The flatness of the landscape with few contour changes influences the water flow and drainage pattern of the area, where there is a profusion of meandering watercourses with somewhat ambiguous direction.

The Macquarie River divides Mount Harris from the other Mounts. This is important in relation to the tribal boundaries, where the Kawambarai and Wongaibon groups are described as sharing a boundary along that part of the Macquarie. The west bank of the Macquarie River is described as belonging to the Kawambarai, who are reported to be closely related to the Wiradjuri, and the area around Warren to Cobar is described as Wongaibon land. The Wongaibon tribal area has an area of 70,000 square kilometres and is larger than that of the other tribal groups around Warren.

Early European settlers (Towle 1939, 206) report the Mounts as meeting places of Aboriginal groups from the Bogan River and Macquarie River, with stone implements from the manufacturing sites being bartered. Whether one group had access to stone from one Mount and another group had stone from another Mount is not known. The organisation of production may be different at the three separate sources, but use the same kind of raw material. For this reason there is a need to systematically investigate these sources at Warren to obtain a contrasting data set. The opportunity to conduct a research program at Mount Harris and Mount Foster was beyond the scope of this study. Observation and recording did take place as a preliminary exercise at Mounts Harris and Foster. But archaeology (as archaeologist's often observe) is an opportunistic discipline and the opportunity arose for comparing and contrasting between Gulgong and Warren. This approach assumed there to be no difference between the three mounts in the comparison values established for Gulgong and Warren. So the three mounts will be treated equally in their comparison with other quarries. My study of the Aboriginal stone quarries at Warren was done on the material at Little Mount. Little Mount is on a stock route running along the west side of the Macquarie River. Held as Crown Land, permission was given for me to work at Little Mount.

The archaeological material and sites as features of relevance to my study of axe making and distribution at the Warren quarries are: other sources of stone; stone materials at campsites; axes found in the area; and stone arrangements. I have chosen these archaeological features because they provide the most opportunity to provide supporting data and information on the nature of production at the Little Mount quarry, and on the distribution system for the axes. For example, grinding material found at campsites gave information on the tools available for finishing and rejuvenating the bevel edges of axes, and the close proximity of stone arrangements suggested the possibility of ceremonial activities related to the axe quarry.

As an economic behaviour to make and distribute axes, the scarcity of stone in the region where the Warren Mounts are located is important in my evaluation. In the landscape of the present Western Division the concept of scarcity in resources is a relative one and has an organisational aspect. For example, in the areas around the Lower Macquarie and adjoining creeks there is an abundance of stone for axes and blades and flakes from cores at the Mounts. From this point in every direction the landscape has good food resources. But other sources of stone for large flake tools is scarce (Witter 1992b). This feature was commented on by Gresser (1962, 532) with there being 'no other stone whatsoever'. Exceptions to this scarcity of stone are found in a few pebble banks and gibber stone beds. There is always the possibility of small outcrops of suitable material or the use of type of material not often used. Witter (1992b) describes a supply of basaltic cobbles from the Dubbo-Narromine area, which were made into axes. But generally the region has no native stone of a quality and size suitable for axes.

An exception to this is an outcrop of granitic material reported from the 'Lemon Grove' property next to 'Thornwood' (Adamson 1964) (see Figure 3.11). The stone source is interesting because the Australian Museum collection of axes for the Warren region includes an axe (Australian Museum #E50614 in Figure 3.13) on which edge has been ground and this granitic material may be from the outcrop.

Apart from the axes in the Australian Museum collection there are few axes recorded from the local landscape. The axes in the Australian Museum collection from the Warren district and Lower Macquarie River are described in Table 3.4. Towle (1939) reports farmers having seen or collected dark or exotic axes, and Gresser (1964) records a pebble axe from Marthaguy Creek near Warren (see Figure 3.11), and bifacial axe preforms from this part of the Macquarie River. I was able to see collections of axes from two properties and an area near Brewarrina.

Property owners, Ted and Margaret Johnstone from 'Wirroona' near Carinda, hold a small collection of axes and preforms from the property, and from their property near the Macquarie Marshes (see Figure 3.11). The 'Thornwood' property is on the west side of the Macquarie River where it runs through the Marshes. From here some years ago a preform of quartz feldspar porphyry from the Warren Mounts was collected (see Figure 3.14). The other axes in the collection were of interest, and one was a dressed axe of the type of material found at the Warren Mounts (see Figure 3.15). The axe was found at the 'Wirroona' property, and is edge ground with use marks on the edge. 'Wirroona' is next to the Cuddie Spring megafaunal site (Dodson et al 1993), where in field surveys I identified a small flake scatter of Warren stone and several isolated flakes (Figure 3.16).

The other axes collected at 'Wirroona' were all of a type of black basaltic or igneous material usually described as 'not local'. The material is described as 'not local' on the basis of local property owners recognising the material as outcropping in the local area. Some of these are edge ground axes, and some are preforms not edge ground. One collected specimen is a hammerstone, and another is a shaped edge-ground axe with anvil pitting on both faces (see Figure 3.17). The axe used as an anvil stone illustrates the generally recognised lack of stone in the Western Region of NSW.

The other collection of axes from the district are collections from the area between Brewarrina and Carinda, held by Roy and June Barker at Gongolgon. No material from the Warren mounts was recognised here, but the collection had four axe preforms with no edge grinding on them and a discoidal shaped axe (Figure 3.18). This thin disc axe seems to fit the style of those described by Roth (1897 (1984)) as coming from the Mount Isa-Cloncurry area, which is possibly Moondarra, by travelling along the Paroo River to the Bogan River. Gresser (1962; 1964) also reports these unusual shape axes to be found in the area. With a paucity of stone available for axes in the region, I expect axes would be traded in to the area.

My survey of Little Mount shows there are stone slabs of quartz feldspar porphyry material which were used for grinding the axe preforms. There are also probable whetstone or sharpening stones on the site. One kilometre away along the side of Marra Creek there are campsites with burnt claypan fire sites and stone artefact material. There are exotic stones in these campsites, including flakes of chert and quartz, a core, and pieces of grindstone material. Some of the grindstone and whetstone materials are most likely to be from the phyllite material I observed at the New Year Range quarry between Brewarrina and Byrock. The grinding gear was from the sandstone source at Yambacoona. In Figure 3.19, I show material held at the Australian Museum from these two sources which was collected in the Warren district. The movement of material to the Warren quarries seems to match the movement of Warren axes away from the quarries. Yambacoona is a large mount of sandstone near

Brewarrina, which has been extensively quarried for grindstones of the type of material used in food processing. As Witter (1992a) points out, the worn out milling slabs of this material used for food processing, will become the whetstones of the region. The New Year Range and Yambacoona both have associated outcrops of quartzite which has been used for flaking and these are found in campsites in the Warren district.

Flakes of Warren quartz feldspar porphyry stone are reported in a survey of the Macquarie Marshes and the earth mounds of burnt clay found there (Beck 1989). The Marshes and area surrounding Warren have many trees scarred by the removal of outer layers for use as containers and implements. There are also carved trees, which are associated as ceremonial places or burial markers in the Warren area, but there are none in association with stone quarries.

The axe quarries at Warren have associated stone arrangements which have likely ceremonial purposes (Towle 1939; Witter 1992b). The stone arrangements on Mount Foster and Little Mount are mostly piles of stones heaped into cairn stones (Figure 3.20). Towle (1939, 202) records four cairn piles along the top of Mount Foster, and one at Little Mount. The piles are about one metre high and two metres diameter. Mount Foster also had an oval of stones about three metres in diameter and a standing stone arrangement. The standing stone arrangement is an upright slab with three other slabs radiating from the base. The antiquity of these stone arrangements are not known, but they are generally considered to be prehistoric.

The 'Twenty stone' arrangement recorded by Towle (1939) is still intact in a paddock between the Macquarie River and Marra Creek (Figure 3.21). The line of twenty stones of QFP material from the Mounts is five kilometres south of Mount Foster, seven kilometres west of Mount Harris and five kilometres north of Little Mount. The location of the 'Twenty stone' is shown on the map in Figure 3.14. Towle reports there are pans of burnt clay around the twenty stones and there are flakes, some of which have use wear. My observation of the 'Twenty stone' arrangement confirms there are burnt clay pans around the site and a few flakes, some of which are not quartz feldspar porphyry. Along the Marra Creek nearby there are campsites with burnt clay and stone artefacts.

From the suggestion of material movement along the river systems such as the Marra Creek and Bogan River, it is easy to accept axes from Warren found in field contexts and local collections near Brewarrina. The axes at this distance can still be classified as being in the late stages of reduction. They show some signs of use but they are not ground or rejuvenated. The dispersal of Warren axes across the plain where there is a scarcity of stone, and the incidence of Yambacoona and New Year Range grindstones near the Mounts suggests the great potential of the area for providing food resources needed for ceremonies, social interaction and axe making.

In conclusion, the natural resources available around the quarries would support meetings of Aboriginal groups from the region, and the ethnohistorical reports of ceremonies at the sites suggest this took place. The incidence of axes coming from sources at some distance suggests a distribution system does operate in the region, but its influence in the area around the Warren quarries is restricted. The local campsites have materials, like whetstones for tool maintenance, but there are several fixed grinding grooves on the quarry. In spite of these grinding facilities there are bifacially flaked preforms with no edge grinding. The situation suggests the quarries to be a source of stone with many different production trajectories, some of which do not require the bifacially flaked stone to be edge ground at the quarry.

3.8 Summary of data and implications for the research

The Late Holocene exploitation of particular quarries does not seem to depend on size, in that there are large and small quarries in use. The quarries can be expected to be exploited across the surface and not to any great depth. There are not many axe quarries known in NSW, and they are not evenly distributed across the landscape. These are concentrated in the east of NSW, but on the west of the dividing range.

The distribution of stone from quarry sources is extensive and over long distances in some cases. The dispersal of axes from the Mount William and Mount Camel quarries in Victoria is extensive along the Murray-Darling system. There is also a long transfer from quarries in the east of NSW. The distribution from these eastern quarries appears to be north-south and to the west. Some of the axes from the eastern quarries are found in the Wilcannia area of the Western Division of NSW. Mootwingee in this area is a node for the exchange of material goods and ceremonial meetings. Goods may come from, and pass to, the north and the south at this point. The north would connect the area with north-west Queensland and south to the Murray-Darling area.

The axes found in the areas around quarries are not all from those particular quarries. The expectation of axes being moved in to an area of no stone must be balanced against the probability of this dispersal of non-local axes being found all across the landscape, including the areas of stone axe quarries. The distinctive axe stone material from the Mounts at Warren can be recognised in collections of axes from the area, where other non-local axes are also found.

The quarry at Warren exists for different reasons from that of Gulgong. Certainly they are both quarries for the extraction and manufacture of axes, but whereas the output of the Gulgong quarry is dispersed over long distances, the axes from Warren quarries are within a restricted area. Warren axes are found at Carinda which is 130 kilometres north and Dubbo which is 160 kilometres south. The axes from Warren quarries do not spread beyond these points. The few axe specimens known by dispersal include two from Narromine, which are symmetrical and ground on the impact edge (Figure 3.22). The result is large well-formed axes with provision for hafting and no signs of usage on them. The material is unusual in appearance, with no comparable axe materials found in east Australia.

From the results of the survey of the axe distribution, I hypothesise that Gulgong quarry supplies a trade route along which (amongst other things) edge ground stone axes were dispersed over a long distance. The quarry at Gulgong is small when compared with quarries like Mount William in Victoria, but is proposed as part of a dispersal that allowed the output to be incorporated in a distribution system that had an asymmetrical dispersal direction to the west. The larger stone axe quarry at Moore Creek shows evidence of extraction of much raw material for axe production, and this dispersal is in the same direction as the Gulgong axes but over a wider range and in greater numbers. This parallel feature of the Moore Creek (group 2B) and Gulgong (group 10) axes is commented on by McBryde (Binns and McBryde 1972, 94). The Gulgong material is isomorphic in distribution to that of Moore Creek, but fewer axes circulated. The six axe specimens from Gulgong petrographically identified are located in the west of NSW, also near Tamworth, and locally to the quarry. A number of the group 2B Moore Creek axes are found in the area of Currabubula and Breeza on the Liverpool Plains. It is from here that two of the Gulgong group 10 axes were collected. The possibility is that Currabubula was an exchange node into which axes from Gulgong and Moore Creek went into the area and were then traded out.

The quarry at Gulgong could have supplied axes to a trading system maintained by the regular exchange of goods. The trading system was based on the bigger quarry at Moore Creek, to which the quarry at Gulgong acted as as support and supplement. In terms of the economic transactions model, the supply of quarried edge ground axes from Gulgong gave the local Aboriginal groups access to items of the material culture, and the developing system of ceremonial interactions. The dispersal of the product is in a westward direction. The incorporation of Gulgong into a wider and bigger system of dispersal can be contrasted with the known dispersal from another axe quarry in south-east Australia, that of Tia, near Walcha. Figure 3.23 shows the axe quarry and preforms I identified at the site. Tia is located closer to Moore Creek than is Gulgong, but the axes are not incorporated in a wide or distant dispersal pattern, and are found local to the quarry (Binns and McBryde 1972). The possibility is that the Gulgong quarry was exploited as part of the wider dispersal, and the Tia quarry was in someway excluded from the west dispersal.

At Warren the circumstances of production were different from that of Gulgong. I hypothesise that there is no trade outside the region of the quarries, and that axe making was based on interactions between groups at local ceremonies. The paucity of stone for axes in the Warren area (McCarthy 1939; Gresser 1962) must be considered in terms of the quarries at the Mounts which are significant in their size and location. At the Warren quarries, Towle (1939) reports barter as an exchange medium used for stone axes. But other circumstances suggest Warren as a place of local procurement, rather than the barter associated with long distance trade (Horne and Aiston 1924; McCarthy 1939). The circumstances suggesting local procurement of axes from the quarries are found in the distribution of axes. The axes are found in a restricted area of distribution around the quarries. As I will show in Chapters 4, 6 and 7, the nature of the production debris at the Warren quarries appears unorganised and the extent of it is sparse. Procurement at the Warren quarries may be explained by other patterns of behaviour. Axe making may be by visiting groups camped at the nearby creeks, or by groups visiting the area for ceremonial purposes.

In conclusion, from the available data I have made two propositions about the nature of axe making and distribution at Gulgong and Warren: (1) that Gulgong is a participant in a trade network, and that exchange is based on decisions about value-adding in axe distribution from quarries and efficient behaviour in axe making; and (2) that Warren is not a participant in a trade network but draws people to the site for ceremonies and axe making in a local distribution system.

In terms of the production trajectory presented in Chapter 2, the quarry at Gulgong directed most of axe making effort and organisation into the distribution of symmetrical axes made by efficient practices. Some output was not passed into the distribution system, but this is a small quantity of the whole production. In contrast, I predict that at Warren the axes did not follow the same production trajectory as Gulgong. They were made to be offered in local exchange, or as part of ceremonial activities. Because of this, the axes were not symmetrically shaped, and were not made on principles of efficient manufacture with decisions based on value-adding. The scarcity of other stone for axe making led to axes being traded-in to the area, but the system of distribution was ad hoc and not organised as a value-adding economic transaction.

These propositions are tested, and the nature of the distribution system for axes produced at Gulgong and Warren is investigated in Chapters 6, 7 and 8 from archaeological work at the quarries.